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HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

STUDY OF NIAGARA SYSTEM

PART I

BEING FOR PERIOD ENDING OCTOBER 31st, 1921

WALTER J. FRANCIS & COMPANY

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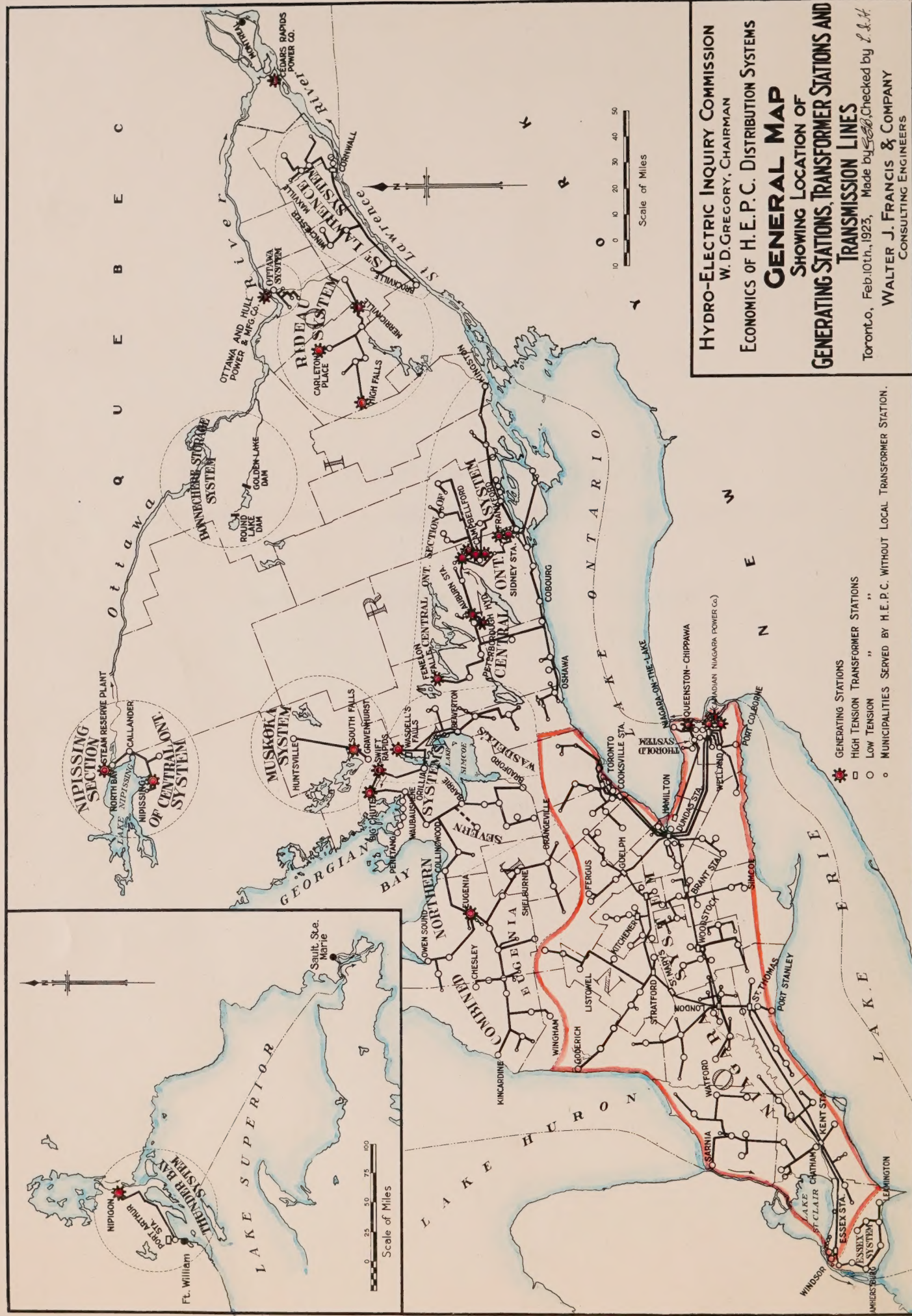
NIAGARA SYSTEM

Part I



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HYDRO-ELECTRIC INQUIRY COMMISSION
W.D.GREGORY, CHAIRMAN

ECONOMICS OF H.E.P.C. DISTRIBUTION SYSTEMS

GENERAL MAP
SHOWING LOCATION OF
GENERATING STATIONS, TRANSFORMER STATIONS AND
TRANSMISSION LINES

Toronto, Feb. 10th., 1923, Made by *E.C.B.* Checked by *L.H.H.*
WALTER J. FRANCIS & COMPANY
 CONSULTING ENGINEERS

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

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Hydro-Electric Power Commission of Ontario.

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Generating Stations, Transformer Stations and Transmission Lines

General Map Showing Location of

Generating Stations, Transformer Stations and Transmission Lines

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GENERAL MAP
of the
LAKESIDE DISTRICT
DISTRIBUTION UNIT



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Toronto, Ontario.

June 15th, 1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman,
TORONTO, Ontario.

re Studies of Engineering Economics of the
Niagara System of the
Hydro-Electric Power Commission of Ontario.

Mr. Chairman and Gentlemen,-

In accordance with the letter to your Commission under date of November 4th 1922, and your confirmation of the general instructions under date of November 15th, 1922, a study has been made of the engineering economics of the Niagara System of electrical transmission and distribution operated by the Hydro-Electric Power Commission of Ontario. The work has been done under the direct personal supervision of Mr. Frederick B. Brown, M. Sc., M.E.I.C., a partner in the firm of Walter J. Francis & Company, in accordance with your instructions.

The subject has been discussed with Mr. Commissioner E. A. Ross in detail, and, generally, with Mr. Bower, the Secretary of your Commission, and constant communication has been maintained with the officials of the Hydro-Electric Power Commission of Ontario.

The reports of Messrs. Price, Waterhouse & Co. have been used as the basis of the financial figures given herein, and reference has been made to the records of the Hydro-Electric Power Commission of Ontario where it was necessary to do so to prepare the diagrams.

1. *Journal of the American Medical Association*, 1997; 277: 1001-1005.

1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 26

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* *Journal of the American Medical Association*, 1970; 213: 1071.

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Elaborated upon in the Appendixes to Volume 2.

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The subject has been discussed with the Commission. It does in itself.

7. *Explain the importance of the following:*

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...of the ... to ...

The results of these tests indicate that the proposed model is a good fit for the data.

of the National Marine Fisheries Service and the U.S. Fish and Wildlife Service.

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to be to prepare the list.

It is understood that it is not within the scope of the instructions to examine into any of the legal aspects of the System nor to discuss any of the Acts of the Legislature relating to it.

The necessary technical data has required considerable preparation as much of it is only available in the operating records of the Hydro-Electric Power Commission of Ontario. The printed reports contain a part, but these have had to be supplemented by interviews with various officials, and by searching the voluminous records both at the head office in Toronto and elsewhere.

The general plan under which the report of the studies is presented may be outlined as follows:

- COPY
- (1) A short review of the history and evolution of the System.
 - (2) A brief physical description of the System.
 - (3) A brief discussion regarding the characteristics of the local market.
 - (4) A discussion of progressive capital costs.
 - (5) Statistics regarding progressive revenues for various classes of service, with discussion thereon.
 - (6) Statistics regarding progressive operating costs and fixed charges, with discussion thereon.
 - (7) Statistics regarding accumulated reserve accounts, with discussion thereon.
 - (8) Statistics showing progressive and accumulated deficits or surpluses, with discussion thereon.
 - (9) Analysis of progressive operating records and of unit revenues per horse-power per annum and of unit costs per horse-power per annum.

(10) A brief discussion of the various important points concerning
the System.

The report included herewith as pages 4 to 82 inclusive refers in detail to that portion of the activities of the Hydro-Electric Power Commission of Ontario known as the Niagara System, up to the period ending October 31st, 1921. The study of the Niagara System for the period commencing November 1st, 1921, is dealt with in a subsequent volume under date of June 23rd, 1923. References are made to the inter-connection of this System with other Systems.

Throughout the report diagrams have been included in the order of the text, while the map included as a frontispiece shows the System generally and its geographical relation to all the other Systems operated by the Hydro-Electric Power Commission of Ontario.

COPY

(2) A brief statement of the various points raised

the system

The system is based on the principle of the

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NIAGARA SYSTEM

Frederick B. Brown, M. Sc.

Evolution and Development of the System.

At the beginning of the present century, when the possibility of transmitting large amounts of power at reasonable cost to consumers at great distances from the generating stations was first being realized, it was felt by the manufacturers in south-western Ontario that the water power of Niagara Falls should be utilized to supply electric power to municipalities and other consumers, at considerable distances from the Falls.

In 1900, the Toronto Board of Trade appointed a committee to investigate the matter. The committee presented a favourable report, and public meetings were held subsequently at which a number of municipalities were represented, with the result that in 1903 the Provincial Legislature passed an Act authorizing the interested municipalities to appoint a commission to make a thorough investigation of the whole power situation. The desired commission was appointed and was called "The Ontario Power Commission". It made a very full report in 1906, considering in detail the various sources of primary power, coal, gas, oil and water, the prospective markets for power in Ontario and the cost of development at Niagara Falls. The report favoured the development of municipally-owned generating plants and transmission and distributing systems for the towns within transmission distance of Niagara Falls.

In 1905, the Provincial Government created the first Hydro-Electric Power

MEMORANDUM

Prepared by Mr. J. Allen Ross.

PROPOSED REVISIONS OF THE REPORT

At the beginning of the present century, when the possibility of trans-
mitting large amounts of power by means of high voltage direct current
systems was first seriously considered, it was believed that the water power of Niagara
by the construction of a high-voltage direct current system, the water power of Niagara
could be utilized to supply electric power to neighboring cities and states.
At that time, the only form of transmission known to the public for transmitting
the energy was the alternating current system, and this system
was not considered as well adapted to transmitting power over long distances.
It was not until the late 1880s that the possibility of transmitting power by means of
high-voltage direct current systems was seriously considered. At that time, the
investigation of the water power of Niagara was being conducted by the
Niagara Falls Commission, and it was found that the water power of Niagara
could be utilized to supply electric power to neighboring cities and states.
At the time this investigation was being conducted, the water power of Niagara
was not considered as well adapted to transmitting power over long distances.
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high-voltage direct current systems was seriously considered. At that time, the
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Niagara Falls Commission, and it was found that the water power of Niagara
could be utilized to supply electric power to neighboring cities and states.

Commission of Ontario, which submitted five comprehensive reports covering the possibilities of power supply in different sections of the Province.

Following the publication of these reports, the present Hydro-Electric Power Commission of Ontario was appointed in 1906, with power to enter into contracts with municipal and other corporations for the transmission and supply of electric power. Since this date the powers of the Commission have been extended and amended, and its operations have grown to vast proportions. In 1906, by-laws were passed in a number of cities, towns and villages, authorising the Corporations and their Councils to make contracts with the Hydro-Electric Power Commission of Ontario for a supply of electrical power to be transmitted from Niagara Falls.

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By "The Power Commission Act", passed by the Legislative Assembly of the Province of Ontario on April 20th, 1907, the Hydro-Electric Power Commission of Ontario was authorized, under trusteeship to the municipalities receiving power, to construct generating plants, transformer stations, transmission lines and distributing stations for the purpose of generating, transmitting and distributing power to municipalities in Ontario.

On March 29th, 1909, "The Power Commission Amendment Act, 1909" was passed amending the 1907 Act referred to above, and validating the Agreement dated May 4th, 1908, between the Hydro-Electric Power Commission of Ontario and the Municipal Corporations of Toronto, London, Guelph, Stratford, St. Thomas, Woodstock, Kitchener, Galt, Hespeler, St. Mary's, Preston, Waterloo, New Hamburg and Ingersoll, by which the Commission agreed among other things to construct a line to transmit electrical energy from Niagara Falls to the Municipal Corporations,

and to have this electrical energy available in the municipalities on the 19th day of March 1910, in such quantities as the municipalities had requested. Further details of this agreement are given in Exhibit X of the report by Messrs. Price, Waterhouse & Co. on the "Investigation of the Accounts of the Niagara System", dated October 9th, 1922.

In 1906, when the Hydro-Electric Power Commission of Ontario invited the hydro-electric power companies at Niagara Falls to submit a price on 100,000 electrical horse-power to be delivered to the Commission, the lowest tender was received from The Ontario Power Company of Niagara Falls. A contract was, therefore, entered into between the Commission and the Company on March 19th, 1906, for a maximum of 100,000 horse-power to be taken in certain blocks as required. This contract fixed the rate for 12,000-volt power at \$9.40 per horse-power per annum up to 25,000 horse-power, and at \$9.00 per horse-power per annum for all the power when the amount reserved and held ready for delivery upon the order of the Commission totalled 25,000 horse-power or more. An additional charge of \$1.00 per horse-power per annum for power delivered at 60,000 volts was agreed upon. The duration of the contract corresponded with the water lease of the Company from the Queen Victoria Niagara Falls Park Commission, which was granted for a term of 50 years, commencing April 1st, 1900, with three optional renewal periods of 20 years each, making the total period under the option 110 years extending to April 1st, 2010.

Power was first delivered to the Niagara System's step-up station from The Ontario Power Company on August 25th, 1910, and on October 11th, 1910, power was officially delivered to Berlin, (now Kitchener), over the 110,000-volt lines

under the option 110 years extending to April 1st, 2010.

between Niagara Falls and Berlin by way of Dundas, Guelph and Preston. During the month of November power was supplied to the Municipalities of Guelph, Woodstock, Preston and Waterloo; London, Stratford and Hamilton were connected to the System in December, and on February 24th, 1911, power was first delivered to the Toronto substation. By October, 1911, twenty municipalities and two industrial corporations were supplied by the System, and about 12,000 horse-power was being delivered to the Hydro-Electric Power Commission by The Ontario Power Company; in 1912 the power delivered was about 30,000 horse-power; in 1914, 68,000 horse-power; in 1915, 94,000 horse-power was taken by 85 municipalities and on March 25th, 1916, the amount of power, ordered to be held in reserve by The Ontario Power Company for the Hydro-Electric Power Commission of Ontario for the supply of the Niagara System, reached the total of the 100,000 horse-power available under the contract of March 19th, 1908.

When it was evident that the full amount of 100,000 horse-power available from The Ontario Power Company would be entirely absorbed by the Niagara System it became necessary to provide for additional power. The Hydro-Electric Power Commission of Ontario, having decided to ask for authority to develop its own power on a large scale, laid a proposal to that end before the Provincial Government in 1913. Powers enabling the Commission to proceed with the project as outlined were obtained in 1914, but it was not until 1917, under "The Ontario Niagara Development Act, 1917, (7 George V, Chap. 21)" that authority was given and work was commenced on what is known as the Queenston-Chippawa Power Development.

In the meantime, the demand for power had grown so rapidly that in 1915

On the morning of the 1st of January, 1917, the following was received from the Department of the Interior:

Very respectfully,
J. Edgar Hoover

On the morning of the 1st of January, 1917, the following was received from the Department of the Interior:

Very respectfully,
J. Edgar Hoover

it was necessary to purchase a temporary supply of 16,000 horse-power from the Toronto Power Company; in 1916, 80,000 horse-power additional was obtained from the Canadian Niagara Power Company, and this 80,000 was all sold by January, 1917.

On August 1st, 1917, the Hydro-Electric Power Commission purchased the capital stock of The Ontario Power Company of Niagara Falls, and immediately made plans to increase its capacity by the construction of a third pipe line and the installation of two new units of 12,000 kilowatts each. The extension was completed in 1919, and the capacity of The Ontario Power Company was increased by about 40,000 horse-power to a total of approximately 200,000 horse-power.

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The contract with the Canadian Niagara Power Company was increased to 80,000 horse-power in 1919, and, in 1920, the Commission in conjunction with the City of Toronto began negotiations for the purchase of the Toronto Power Company. By the end of 1921, the Commission found it necessary to purchase additional power at Niagara Falls under day-to-day contracts to the extent of 90,000 horse-power.

Operation of the new Queenston-Chippawa plant commenced in December 1921, with No. 1 generator of 45,000 kv-a. capacity. Four other generators of like capacity are now in operation, No. 2 having started in March, 1922; No. 3 in October, 1922; No. 4 in November, 1922; and No. 5 in April, 1923, completing the initial development of about 300,000 horse-power. Generator No. 6 is under construction, and is expected to start running in the spring of 1924. Units Nos. 7 and 8 have been ordered in anticipation of being in service late in 1924.

On April 20th, 1922, an accident occurred in the plant of The Ontario Power

It was decided to increase a temporary supply of 11,000 barrels per day to 12,000 barrels per day in 1961, and to 13,000 barrels per day in 1962. The total supply of 13,000 barrels per day was to be maintained through 1963.

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and there is evidence for the involvement of a third type of cell

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Journal of the American Statistical Association, Vol. 94, No. 447, December 1999, pp. 1303-1314

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Company which completely destroyed the two new units Nos. 15 and 16, and reduced the capacity of the plant to about 175,000 horse-power until one or both units will have been replaced. A number of other machines were damaged by water and the temporary reduction in capacity was much greater than 25,000 horse-power.

Further details regarding the purchase, the land involved, the purchase of the Toronto Power Company.

The terms of the purchase of the properties of the Toronto Power Company, known as the "clean-up deal", are stated in a letter dated December 3rd, 1920, from Sir Adam Beck addressed to the Mayor and Board of Control of the City of Toronto. In this letter it is stated that the Hydro-Electric Power Commission of Ontario had decided to recommend the purchase of the properties and an outline is given of some of the principal features. The proposed purchase by the Hydro-Electric Power Commission of Ontario was to include the following:

1. For and behalf of the municipalities comprising the Niagara System:

"The Electrical Development Company's generating plant at Niagara Falls, the Toronto and Niagara Power Company's transformer stations and transmission lines and the steam plant, lands and property in the City of Toronto at a total price of \$22,547,705"

2. For and on behalf of the City of Toronto:

"The distribution system of the Company in the City of Toronto at the price of \$7,225,295, and the section of the Metropolitan Division of the Toronto and York Radial Railway Company within the city (limited to what lies on the Highway) at the price of \$385,000, or a total of \$7,610,295"

"The properties of the Toronto and York Radial Railway Company including the Metropolitan Division (except the section on the Highway within the city limits), the Scarborough Division and the Mimico Division for the sum of \$2,375,000"

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1. The first of the two conditions mentioned in the text is that the system must be in a state of equilibrium. This is a necessary condition for the application of the second law of thermodynamics.

The following information was obtained from the records of the Bureau of Prisons, Washington, D.C., dated May 19, 1960:

On May 19, 1960, the following information was received from the Bureau of Prisons, Washington, D.C.:

On May 19, 1960, the following information was received from the Bureau of Prisons, Washington, D.C.:

2. Not and on behalf of the City of Toronto.

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These sums make up a total purchase price of \$32,734,000, for the properties and businesses of the various companies owned or controlled by the Toronto Railway Company, namely, the Toronto Power Company, the Electrical Development Company, the Toronto and Niagara Power Company, the Toronto and York Radial Railway Company and the Schomberg and Aurora Railway Company.

Further details regarding the properties, the bond issues, the terms of payment, and so forth, are given in the letter.

In the broadest sense the Niagara System at the present time may be said to embrace:

(a) The complete ~~Queenston-Chippewa~~ **COPY** Power Development with a peak capacity now installed of about 300,000 horse-power, and which during the years 1923-1924 will likely be increased to about 450,000 horse-power.

(b) The generating plant, transformer stations, transmission lines, property and so forth, which are controlled by the Hydro-Electric Power Commission of Ontario through its ownership of the entire capital stock of The Ontario Power Company of Niagara Falls and its subsidiary The Ontario Transmission Company, Limited. The capacity of this plant is about 175,000 horse-power, and is being increased to about 190,000 horse-power by the reconstitution of one of the generating units destroyed in the accident of April 20th, 1922.

(c) The generating plant, transformer stations, transmission lines, property, etc., which are controlled by the Hydro-Electric Power Commission through the purchase of the Toronto Power Company. The capacity of this plant is about 125,000 horse-power.

(d) The right-of-way, transformer stations, transmission lines, distributing

stations, and so forth, constructed for the purpose of transmitting and distributing power to the various municipalities and companies on the System, and

(c) The Niagara Rural Lines, which consist of primary or main lines constructed by the Hydro-Electric Power Commission of Ontario to supply electrical power to customers adjacent to certain municipalities.

The Niagara System proper, however, consists only of items (d) and (e) and, therefore, does not include any generating stations, except the very small Brindale plant on the Credit River. At October 31st, 1921, it included 466.9 miles of 110,000-volt steel tower lines, and 1007.88 miles of lines of 46,000 volts or lower voltages constructed on steel and on wooden supports; the main transformer station at Niagara and fifteen step-down transformer stations supplying sixty-five distributing stations as listed on pages 26 to 29, with a total capacity of about 600,000 kv-a., including reserves. The System in 1921 was supplying 159,149 horse-power to one hundred and twenty-two municipalities, and 43,371 horse-power to twenty-four private companies and others, and to the Essex System, and in 1922 these figures were 190,623 horse-power and 31,912 horse-power, respectively.

Description of the System.

General.

The Niagara System lies immediately north of Lake Erie and extends from Lake Ontario to Lake Huron. The maximum extent east and west is about 225 miles

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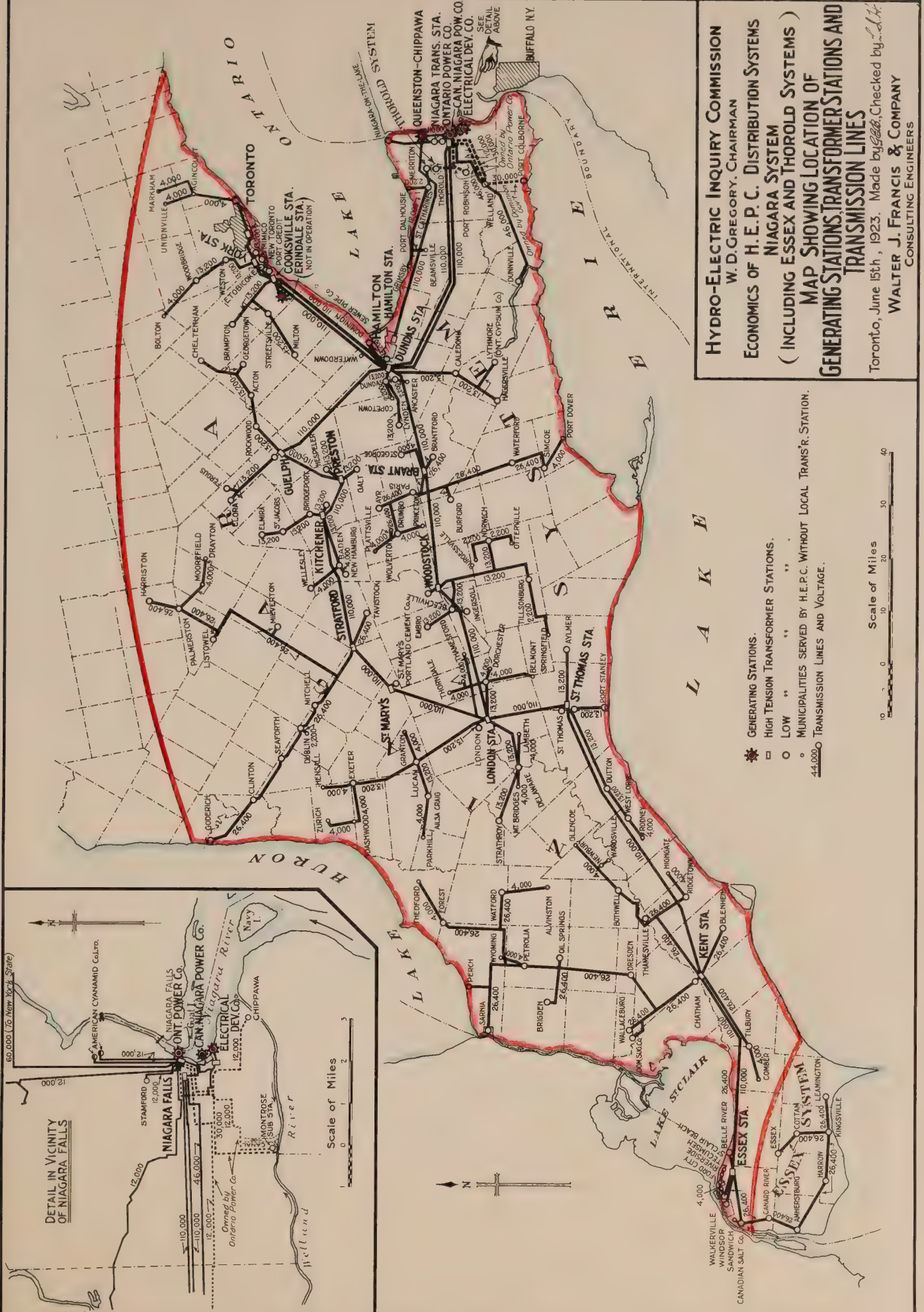
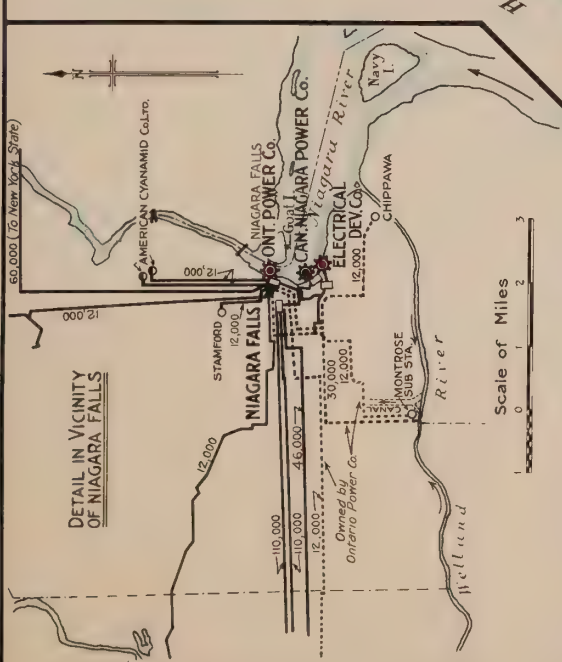
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from Toronto and Niagara Falls on the east to Sarnia, Chatham and Windsor on the west. At the extreme western tip of the Niagara System is the Essex System, which is supplied with power from the Essex transformer station of the Niagara System. On the north the Niagara System is bounded by the territory included in the "Combined Northern Systems", namely the Eugenie, Severn and Wasdell's Systems.

The map included as a frontispiece shows the whole of the transmission systems of the Hydro-Electric Power Commission of Ontario with the location of generating stations, high voltage transformer stations, high voltage transmission lines and low voltage distributing stations clearly indicated and shows the various Systems in their relation to one another. The tinted portion of the map indicates the Niagara System.

The map included as page 13 shows the Niagara System on a larger scale than the frontispiece and gives also the names of the principal centres concerned.

Speaking generally, the Niagara System consists of a step-up transformer station receiving power from a number of generating stations at Niagara Falls, including the Queenston-Chippawa Power Development, a network of 110,000-volt and lower voltage transmission lines, which were furnishing power, at October 31st, 1921, to fifteen step-down transformer stations supplying one hundred and twenty-two municipalities, to the London Railway Commission, to twenty-four companies and other private consumers, and to the Essex System.



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
NIAGARA SYSTEM
(INCLUDING ESSEX AND THOROLD SYSTEMS)
MAP SHOWING LOCATION OF
GENERATING STATIONS, TRANSFORMER STATIONS AND
TRANSMISSION LINES

Toronto, June 15th, 1923. Made by *W.D.G.*, Checked by *L.H.*
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Generating Stations and Other Sources of Power Supply.

The Niagara System in its broadest sense includes three large and one small hydro-electric generating stations: The Ontario Power Company of Niagara Falls, with a present capacity of about 175,000 horse-power, which is now being reconstituted to about 190,000 horse-power; the Toronto Power Company, also known as the Electrical Development Company, with a capacity of about 125,000 horse-power; the Queenston-Chippawa Power Development with a present installed peak capacity of about 300,000 horse-power; and the Brindale plant on the Credit River. It also has available some purchased power from the Canadian Niagara Power Company at Niagara Falls.

(a) The Ontario Power Company of Niagara Falls.

The hydro-electric development of The Ontario Power Company of Niagara Falls is located on the Canadian side of the Niagara River in the immediate vicinity of the Horseshoe Falls, the headworks being about a mile above the Falls, and the power house in the gorge a short distance downstream from the Falls.

The headworks, consisting of an intake, an outer forebay, a screen house, an inner forebay and a gate-house are built of concrete and stonework and the principal buildings are monumental in design.

Three underground conduits or pipe lines convey the water from the headworks to the penstocks leading to the turbines in the power house. The pipe lines are approximately 6,500 feet in length, and have a total drop of 28 feet from the headworks to the inlets of the penstocks.

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From the perspective of the future of the peninsula.

The water is admitted to the pipe lines by means of stoney sluice head-gates, there being one head-gate for each pipe line, all located in the gate-house. A surge tank is connected to each pipe line.

Sixteen steel penstocks, embedded in concrete, carry the water from the pipe lines to the main generating units in the power house, one penstock for each main unit.

The power house is about 780 feet long and is located at the water's edge at the base of the cliff.

In the original plant as purchased by the Hydro-Electric Power Commission of Ontario, on August 1st, 1917, there were fourteen main units, all three-phase, 25 cycles, 12,000 volts. **COPY** Generators Nos. 1 to 3 were 7,500 kilowatts each, generators Nos. 4 to 14 were 8,776 kilowatts each, and the nominal maximum capacity of the plant was about 160,000 horse-power. The third conduit or pipe line together with units Nos. 15 and 16 were completed in 1919, each of the generators being of about 12,000 kilowatts capacity. The addition of the two new units and the improvement in the water supply to the remaining units increased the capacity of the plant to about 200,000 horse-power, with everything running to full capacity and with no spare units.

The accident to the two 12,000-kilowatt generators on April 20th, 1922, temporarily reduced the capacity of the plant to about 175,000 horse-power. The gross head of the development is about 215 feet, and accepting the value of 15 horse-power generated per cubic foot of water per second, the overall efficiency of the plant is about 61 per cent.

The liabilities of the Hydro-Electric Power Commission in respect to The

at the base of the cliff.

The following table shows the results of the survey of the water supply of the State of California, as conducted by the State Engineer, under the authority of the Legislature, in the year 1905. The table is divided into two parts, the first showing the results of the survey of the water supply of the State, and the second showing the results of the survey of the water supply of the various counties of the State.

It is estimated that the plant is about 10 per cent.

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Ontario Power Company amounted to about \$31,000,000 at October 31st, 1921.

(b) The Toronto Power Company.

The Electrical Development Company station referred to as part of the Toronto Power Company was built by the Electrical Development Company, the first four 14,000 horse-power units being installed in 1906 and 1907 and seven 15,500 horse-power units being added between 1910 and 1914. The plant was operated under lease to the Toronto Power Company, Limited, from April, 1908, until its acquisition by the Hydro-Electric Power Commission under the terms of the agreement signed August 15th, 1922.

This hydro-electric plant includes a concrete wing dam at the head of the falls, 785 feet long and 27 feet high. The water is led through 10-foot steel penstocks to a wheel-pit 416 feet long, 22 feet wide and 150 feet deep. The tail water is discharged through twin tunnels, 28 feet in diameter, converging below the power house into a single tunnel 1,935 feet long with an outlet at the foot of the Horseshoe Falls. The power house, built of Indiana limestone, is of ornate and imposing design, and is 500 feet long and 70 feet wide. The plant installed is as follows: Turbines - four I. P. Morris, 69-inch vertical double-runner, 250 r.p.m., 14,000 h.p. each; seven I. P. Morris, 75 3/4-inch, vertical, double-runner, 250 r.p.m., 15,500 h.p. each; total 164,500 h.p.; Generators - four Canadian General Electric, 3-phase, 25-cycle, 12,000-volt, 250 r.p.m., 8,000 kv-a. each; seven Canadian General Electric, 3-phase, 25-cycle, 12,000-volt, 250 r.p.m., 10,000 kv-a. each; total 102,000 kv-a.; Exciter Turbines - two I. P. Morris, 27 3/4-inch, vertical, 500 r.p.m., 500 h.p. each,

total 1,000 h.p.; Exciter Generators - four Canadian General Electric, D.C. 125-volt, 500 r.p.m., 300 kw. each (two being driven by the exciter turbines and two being motor-driven); and eleven direct-connected exciters, one on each of the main units; Station Transformers - three banks of three Canadian General Electric, single-phase, 2670 kv-a. each, 12,000 to 60,000 volts; three banks of two Canadian General Electric single-phase, 6,000 kv-a. each, 12,000 to 60,000 volts; total 50,000 kv-a.

It is stated by the engineers that the Electrical Development Company plant operates under an average head of about 130 feet, and that it operates continuously at a load factor of almost 100 per cent. The auxiliary steam power station located in Toronto was originally installed by the Toronto Electric Light Company in 1883, but the present units were installed as follows: two 2,700 h.p. units in 1912, one 10,000 h.p. unit in 1913, and one 8,700 h.p. unit in 1916.

It is variously estimated that an amount between 12,500 and 13,300 cubic feet of water per second is required to produce approximately 146,000 horse-power, the larger figure giving about 11 horse-power per cubic foot per second. The best efficiency of the plant is stated by the engineers to be obtained at an output between 100,000 and 120,000 horse-power. According to the agreement with the Queen Victoria Niagara Falls Park Commissioners the amount of water permitted to be diverted by the Electrical Development Company is that required to produce 125,000 horse-power.

(c) The Queenston-Chippawa Power Development.

The Queenston-Chippawa Power Development, the power house of which is situated near Queenston, constructed by the Hydro-Electric Power Commission of

Ontario, is the first on the Niagara River to utilize the full head available between the level of Lake Erie and that of Lake Ontario. The water is diverted from the mouth of the Welland River at an elevation of approximately 532.5 feet above sea level, while the tail waters are discharged at an elevation of 245.5, an average difference in elevation of 317 feet. The average effective net head at full capacity is estimated to be 305 feet. The generating units are designed to give maximum output at as low as 294 feet head.

The power plant is located about one mile upstream from Queenston. The water is brought from the Lake Erie level to the power house by means of the Welland River for about four miles, and by a canal between the river and the forebay located adjacent to the power house but on the upper level.

The intake for the development is at the mouth of the Welland River and the engineers of the Commission have provided for admission of water by submerged tubes should ice troubles materialize during the early years of operation. Meanwhile the intake will be operated in the usual way as a submerged boom structure.

The canal between the Niagara River and the entrance to the forebay is 65,237 feet in length. The capacity of the intake and canal was designed to insure a working flow of at least 15,000 cubic feet per second, but the engineers of the Hydro-Electric Power Commission and their advisory engineers believe the flow will exceed this amount, some calculating it at over 18,000 cubic feet per second. A discussion of this point in detail will follow in a report by Mr. Walter J. Francis.

The screen house is placed 75 feet back from the edge of the gorge and

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THE UNITED STATES DEPARTMENT OF THE INTERIOR
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provision is made in the design for either nine or ten main inlets for the penstocks to the main turbines and for two inlets for penstocks for service turbines. Each main inlet is divided into three sections by piers and in each section there is a screen, upstream from which slots for stop-logs are provided.

The upper two-thirds of each main penstock is 16 feet in diameter and the lower third is 14 feet. The distance from the inlet screens to the centre line of the turbines is about 460 feet. The penstocks are covered with eighteen inches of concrete and at the lower end of each a Johnson valve is installed.

The generating station is at present completed for five vertical-shaft units nominally of 55,000 horse-power each. It is later proposed to install either four or five additional units of similar capacity, making the ultimate installed plant capacity about 550,000. The present turbines are designed to operate at 187.5 revolutions per minute under a head of 305 feet, and they have a guaranteed efficiency of 88 per cent.

Each turbine is directly connected to a 45,000 kv-a., 12,000-volt, 3-phase, 25-cycle generator. Current limiting reactors are provided between generators on the 12,000-volt bus. The generators show very high efficiencies, and the overall efficiency of the generators, turbines, and switchgear from the water to the 12,000-volt bus bars is apparently over 90 per cent. Transformers step up the voltage to 110,000 volts to supply power to the Niagara System.

With a net head of 305 feet between the forebay and the lower river, the output per cubic foot of water per second at 90 per cent. efficiency is

1. The Commission has received information from the Department of the Interior that the Bureau of Land Management is planning to acquire certain lands in the State of California for the purpose of establishing a national monument. The lands in question are located in the County of San Diego and are owned by the State of California. The Commission is of the opinion that the acquisition of these lands is in the public interest and that the establishment of a national monument is a desirable project. The Commission has therefore recommended that the Department of the Interior be authorized to acquire the lands in question for the purpose of establishing a national monument.

approximately 31 horse-power delivered at the low voltage bus bars.

The liabilities of the Hydro-Electric Power Commission with respect to the Queenston-Chippawa Development amounted to about \$58,000,000 at October 31st, 1921, and about \$62,000,000 at March 31st, 1922. The total capital cost with about 550,000 horse-power nominal installed capacity when completed will probably be of the order of \$75,000,000 or \$80,000,000.

(d) The Brindale Plant.

The Brindale hydro-electric plant, situated on the Credit River, was installed in 1910 with a capacity of about 1,600 horse-power. The plant formerly operated under an average head of 55 feet, but this head has been reduced owing to unrepaired damages to the dam structure. Auxiliary power was obtained from the combined steam and hydraulic plant of the Interurban Electric Company, near Lambton, Ontario.

The development consists of an earth dam with a concrete core, 700 feet long and 35 feet high, from which a 900-foot tunnel leads to a storage tank immediately adjoining the concrete power house. Two 850 horse-power turbines are direct-connected to two 600-kilowatt, 3-phase, 60-cycle, 13,200-volt, generators. The plant is operated from one to five hours daily during peak loads, and is connected to the Niagara System through a frequency-changer set, the generator of which may be used as a synchronous condenser when required. The Brindale generating station was purchased by the Hydro-Electric Power Commission in 1917, and on December 14th of that year its output was first delivered to the Niagara System.

University of Birmingham

For illustration of the above-mentioned items, reference is made to the following figures:

Item	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1. Total assets	100,000,000	110,000,000	120,000,000	130,000,000	140,000,000	150,000,000	160,000,000	170,000,000	180,000,000	190,000,000	200,000,000
2. Total liabilities	50,000,000	55,000,000	60,000,000	65,000,000	70,000,000	75,000,000	80,000,000	85,000,000	90,000,000	95,000,000	100,000,000
3. Total equity	50,000,000	55,000,000	60,000,000	65,000,000	70,000,000	75,000,000	80,000,000	85,000,000	90,000,000	95,000,000	100,000,000

$$A^{\alpha} = \frac{1}{\Gamma(\alpha)} \int_0^t (t-s)^{\alpha-1} A(s) ds, \quad (1)$$

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(c) The Canadian Niagara Power Company.

The plant of the Canadian Niagara Power Company, from which a large block of power has been and is being purchased for the Niagara System, is situated above the Horseshoe Falls, the headworks being adjacent to the power house. Water is drawn from the Niagara River at a point 500 feet above the crest of the Horseshoe Falls through an excavated intake canal, 406 feet wide and 200 feet long, protected at the entrance by a system of ice shields, and leading to the stone power house which is 72 feet wide by 580 feet long. The turbines are installed in a deep pit and operate under an average head of 128 feet. The water is admitted from the forebay through short penstocks and is discharged from the wheels through a long, underground, brick-lined tunnel of oblate section, 18 feet by 25 feet in section, with its outlet at the foot of the Falls, just below the generating station of The Ontario Power Company of Niagara Falls. Long vertical shafts connect the turbines with the generators, which are installed in the power house at the ground level 122 feet above the turbines. There are ten main units, five of 10,250 horse-power, three of 10,750 horse-power and two of 12,500 horse-power, a nominal total of 109,000 horse-power. It is understood that an eleventh unit is now being installed as a spare. All generators are three-phase, 25-cycle, 12,000-volt units, and have a combined capacity of 89,500 kilowatts. Nearly all of the energy of the plant is sold in bulk at 12,000 volts or at 22,000 volts, the output being divided as follows: Hydro-Electric Power Commission of Ontario, 50,000 horse-power from 1916 to 1922 inclusive and 20,000 horse-power thereafter; Niagara Falls Power Company, 30,000 horse-power to 40,000 horse-power; the Buffalo General Electric Company,

is supplied through the Niagara Falls Lower Company, while the other consumers include the Norton Company, the Canadian Aloxite Company and the Graphite Company, these consumers using the energy for electro-chemical purposes. The plant was constructed in 1904 and additional units were installed in 1913 and 1916. ~~These systems will be used to supply the needs of the S.~~

Between 8,225 and 9,600 cubic feet of water per second is required to develop 100,000 horse-power in the station, the larger figure giving approximately 10.5 horse-power per cubic foot per second.

(f) The International Railway Company.

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The plant of the International Railway Company also derives its energy from Niagara Falls. It includes an 8-foot penstock leading to a stone power house where a head of only 65 feet is available. Two turbines of 1,000 horse-power each are belted to five 200-kilowatt, 600-volt direct-current generators, and one turbine of 2,000 horse-power is direct-connected to a 1,500-kilowatt, 600-volt, direct-current generator, making a total capacity of 2,500 kilowatts. The power is used by the Company for electric railway purposes, with an annual load factor of about 29 per cent. This plant was installed in 1893 and was extended about 1899. The peak load in 1921 was said to be 1,200 kilowatts, requiring probably 300 to 400 cubic feet of water per second.

Parallel Operation of the Niagara System with Other Systems.

All the stations supplying the Niagara System generate power at 25 cycles.

while the other Systems of the Hydro-Electric Power Commission of Ontario are supplied at 60 cycles. When the loads on the adjacent Systems increase beyond the capacity of the local generating stations power must be supplied to them from outside sources, and it seems likely that the available excess capacity of the Niagara System will be used to supply the needs of the Hugenia, Severn, and Wasdell's Systems; but frequency-changers will be required to transform from 25-cycle to 60-cycle power. The Essex System is now supplied at 25-cycles from the Essex transformer station of the Niagara System.

There has been some discussion also regarding the supply of Niagara power to Central and Eastern Ontario, for example to the Central Ontario (Trent) Section of the Central Ontario System near Oshawa.

Undeveloped Power Sites.

The output of power at Niagara cannot be materially increased unless a greater diversion of water from the Niagara River and the Welland River is permitted, or unless the plants were re-located on sites comparable in a hydraulic sense with that of the Queenston-Chippawa plant. The latter course is impracticable at present, and the former would necessitate a revision of international treaty agreements.

The Ontario Power Company is stated to be able to develop about 15 horse-power per cubic foot of water per second; the Toronto Power Company about 10 horse-power per cubic foot per second; and the Canadian Niagara Power Company about 10.5 horse-power per cubic foot per second. If no additional diversion of water is allowed by international agreement it would seem to be advisable

to use the available water so far as economically feasible under the maximum head.

The present total diversion on the Canadian side is capable of developing considerably over 1,000,000 horse-power, if used at the full head with an output of about 30 horse-power per cubic foot per second, as is said to be obtained in the Queenston plant. Under existing conditions without diverting any of the water from The Ontario Power Company or the Toronto Power Company, only about one-half of the above amount can be generated.

Miscellaneous Power Plants in the District.

There are a large number of power plants within the boundaries of the Niagara System. Some have been idle since the System took over the supply of power, and others are in service in municipalities which have not yet joined the Niagara System. A number of the idle plants are available for local use in emergency. The following table gives the location, capacity and ownership of the various plants:

Table of Miscellaneous Power Plants in the District of the Niagara System

Place	Kind of Power	Approximate H.P.	Location	Owner and Remarks
Alvinston	Steam	47	-	Alvinston Power Company.
Arkona	Water	100	Ausable River	Rock Glen Power Company.
Aylmer	Steam	180	-	Municipality.
Blyth	Steam	40	-	Municipality.
Brantford	Water	1100	Grand River	Dominion Power & Trans. Co.
Brussels	Steam	130	-	Privately owned, municipally operated.

[illegible][illegible]

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[illegible]

These results are in line with the findings of other studies that have shown that the use of a single, standardized questionnaire can lead to biased results. The use of multiple questionnaires, such as the one used in this study, can provide a more comprehensive and accurate picture of the research population.

Station	Kind of Service	Approximate Date	Location	Notes and Remarks
Alvinston	Steam	1900	-	Alvinston River Ferryway.
Alvinston	Steam	1900	Alvinston River	First time from Alvinston.
Alvinston	Steam	1900	-	Alvinston River.
Alvinston	Steam	1900	-	Alvinston River.
Alvinston	Steam	1900	-	Alvinston River & Canal, etc.
Alvinston	Steam	1900	-	Privately owned, municipal- ly operated.

Table of Miscellaneous Power Plants in the District of the Niagara System
(continued)

Place	Kind of Power	Approximate H.P.	Location	Owner and Remarks
Chatham (	Steam	400	-	Chatham Gas Company.
(Natural gas engines		1,390	-	
Delhi	Water	290	Big Creek	Delhi Light & Power Company.
Glencoe	Producer Gas	100	-	Municipality.
Guelph	Water	200	Speed River	Municipality.
Hamilton (	Steam	30,000		Dominion Power & Trans. Co.
((Power Glen) Water		52,000	Welland Canal	Dominion Power & Trans. Co.
London	Steam	660	-	Belena Costume Co.
Markham	Steam	98	-	Municipality.
Merlin	Natural Gas	50	-	James McHardy.
Parkhill	Steam	70	-	F. C. Baird & Co.
Sandwich	Steam	1,900	-	Canadian Salt Company.
Stouffville	Producer Gas	55	-	Municipality.
Streetsville	Water	160	Credit River	Municipality.
Theedford	Steam	55	-	George Coultres & Co.
Thorold	Water	160	Old Welland Canal	Municipality.
Toronto Tp. (Erindale)	Water	1,600	Credit River	H. E. P. Co.
Wheatley	Natural Gas	35	-	Marven White.
Windsor	Steam	1,500	-	Sandwich, Windsor and Amherstburg Railway.
Woodstock	Steam	530	-	Municipality.

Transmission Lines.

Up to October 31st, 1921, the Hydro-Electric Power Commission had acquired or constructed 466.9 miles of 110,000-volt steel tower transmission lines, forming a high voltage primary network receiving power from the step-up transformer station at Niagara Falls and feeding fifteen step-down transformer stations which are listed on pages 26 to 29. Four of these stations step the voltage down to 26,400 volts. The remainder transform to 13,200 volts, to

supply the various municipal and other corporations and consumers, comprising the Niagara System, through 91 distributing stations. The secondary distribution lines comprise in all 1,007.4 miles and are constructed on steel and wood supports.

Transforming and Distributing Stations.

The main receiving station of the Niagara System is the Niagara Transformer Station at Niagara Falls South, to which power is delivered at 12,000 volts from The Ontario Power Company, the Toronto Power Company, and the Canadian Niagara Power Company. Part of this power is transformed to 46,000 volts to supply four distributing stations, but the larger part is raised to 110,000 volts to supply the high voltage system with its fifteen step-down transformer stations feeding the 87 distributing stations formerly referred to. The various transformer and distributing stations on the Niagara System are listed in the following table which shows also their voltage and capacity. The information was supplied by the engineers of the Hydro-Electric Power Commission and is said to be complete to date.

Table of Transformer and Distributing Stations

Station	Capacity K.V.A.	Voltage
(1) Niagara Transformer Station	167,000 35,000 202,000	12,000/110,000 12,000/46,000
Dunnville Distributing Station	450	46,000/2,300
Niagara-on-the-Lake Distributing Station	150	12,000/2,300
St. Catharines Distributing Station		12,000/2,300
Welland Distributing Station	3,450	46,000/2,300

1. The first step is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the situation.

[illegible]

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	

Table of Transformer and Distributing Stations (Continued)

Station	Capacity K.V.A.	Voltage
(2) Dundas Transformer Station	17,500	110,000/13,200
Caledonia Distributing Station	450	13,200/2,300
Dominion Sewer Pipe Co. (Waterdown) Distributing Station	225	13,200/2,300
Hagersville Distributing Station	(450)	13,200/2,300
	(300)	13,200/4,000
Lynden Distributing Station	225	13,200/4,000
Ontario Gypsum Co. Distributing Station	225	13,200/550
(3) Toronto Transformer Station	75,000	110,000/13,200
(4) London Transformer Station	17,500	110,000/13,200
Ailsa Craig Distributing Station	225	13,200/4,000
Delaware Distributing Station	75	13,200/4,000
Dorchester Distributing Station	225	13,200/4,000
Exeter Distributing Station	300	13,200/4,000
Lucan Distributing Station	225	13,200/4,000
Strathroy Distributing Station	450	13,200/4,000
(5) Guelph Transformer Station	5,000	110,000/13,200
Acton Distributing Station	225	13,200/2,300
Cheltenham Distributing Station	225	13,200/575
Elora Distributing Station	225	13,200/4,000
Fergus Distributing Station	225	13,200/2,300
Georgetown Distributing Station	450	13,200/4,000
Rockwood Distributing Station	75	13,200/2,300
(6) Preston Transformer Station	3,000	110,000/13,200
	2,250	110,000/6,600
	5,250	
Galt Distributing Station	3,375	13,200/2,200
Hespeler Distributing Station	510	13,200/4,000
South Waterloo Township Distributing Station	225	13,200/4,000
(7) Kitchener Transformer Station	16,750	110,000/13,200
Baden Distributing Station	450	13,200/4,000
Bridgeport Distributing Station (Fed by Kitchener)		
Elmira Distributing Station	450	13,200/4,000
New Hamburg Distributing Station	225	13,200/2,200
St. Jacobs Distributing Station	75	13,200/575
Wellesley Distributing Station (Fed by Baden)		

Station	Capacity Tons	Weight Tons
1. New York - New Jersey	10,000	10,000
2. New York - New Jersey	10,000	10,000
3. New York - New Jersey	10,000	10,000
4. New York - New Jersey	10,000	10,000
5. New York - New Jersey	10,000	10,000
6. New York - New Jersey	10,000	10,000
7. New York - New Jersey	10,000	10,000
8. New York - New Jersey	10,000	10,000
9. New York - New Jersey	10,000	10,000
10. New York - New Jersey	10,000	10,000
11. New York - New Jersey	10,000	10,000
12. New York - New Jersey	10,000	10,000
13. New York - New Jersey	10,000	10,000
14. New York - New Jersey	10,000	10,000
15. New York - New Jersey	10,000	10,000
16. New York - New Jersey	10,000	10,000
17. New York - New Jersey	10,000	10,000
18. New York - New Jersey	10,000	10,000
19. New York - New Jersey	10,000	10,000
20. New York - New Jersey	10,000	10,000

Table of Transformer and Distributing Stations (Continued)

Station	Capacity K.V.A.	Voltage
(8) Stratford Transformer Station	5,000	110,000/26,400
Clinton Distributing Station	450	26,400/2,200
Dublin Distributing Station	50	26,400/4,000
Goderich Distributing Station	750	26,400/2,200
Harriston Distributing Station	225	26,400/4,000
Listowel Distributing Station	600	26,400/4,000
Milverton Distributing Station	225	26,400/4,000
Mitchell Distributing Station	225	26,400/4,000
Palmerston Distributing Station	225	26,400/4,000
Seaforth Distributing Station	450	26,400/2,200
Tavistock Distributing Station	225	26,400/575
(9) St. Mary's Transformer Station	3,000	110,000/13,200
St. Mary's Cement Co. Distributing Station	1,950	13,200/575
(10) Woodstock Transformer Station	6,000	110,000/13,200
Beechville Distributing Station	225	13,200/2,300
Habro Distributing Station	50	13,200/4,000
Ingersoll Distributing Station	937	13,200/2,300
Norwich Distributing Station	225	13,200/2,300
Tillsonburg Distributing Station	750	13,200/2,300
(11) St. Thomas Transformer Station	5,250	110,000/13,200
L. & P. S. Railway Rotary Station in St. Thomas Transformer Station	1,665	13,200/920
Aylmer Distributing Station	150	13,200/4,000
Dutton Distributing Station	225	13,200/4,000
West Lorne Distributing Station	225	13,200/4,000
Port Stanley Distributing Station	300	13,200/2,300
(12) Brant Transformer Station	10,000	110,000/26,400
Ayr Distributing Station	225	26,400/4,000
Brantford (City Plant) Distributing Station	2,250	26,400/4,000
Burford Distributing Station	75	26,400/4,000
Drumbo Distributing Station	225	26,400/4,000
Paris Distributing Station	600	26,400/2,200
St. George Distributing Station	300	222/4,000
Simcoe Distributing Station	300	26,400/4,000
Waterford Distributing Station	225	26,400/4,000

(Continued)

Station	Frequency (MHz)	Power (W)
101.1	101.1	100
101.3	101.3	100
101.5	101.5	100
101.7	101.7	100
101.9	101.9	100
102.1	102.1	100
102.3	102.3	100
102.5	102.5	100
102.7	102.7	100
102.9	102.9	100
103.1	103.1	100
103.3	103.3	100
103.5	103.5	100
103.7	103.7	100
103.9	103.9	100
104.1	104.1	100
104.3	104.3	100
104.5	104.5	100
104.7	104.7	100
104.9	104.9	100
105.1	105.1	100
105.3	105.3	100
105.5	105.5	100
105.7	105.7	100
105.9	105.9	100
106.1	106.1	100
106.3	106.3	100
106.5	106.5	100
106.7	106.7	100
106.9	106.9	100
107.1	107.1	100
107.3	107.3	100
107.5	107.5	100
107.7	107.7	100
107.9	107.9	100
108.1	108.1	100
108.3	108.3	100
108.5	108.5	100
108.7	108.7	100
108.9	108.9	100
109.1	109.1	100
109.3	109.3	100
109.5	109.5	100
109.7	109.7	100
109.9	109.9	100
110.1	110.1	100
110.3	110.3	100
110.5	110.5	100
110.7	110.7	100
110.9	110.9	100
111.1	111.1	100
111.3	111.3	100
111.5	111.5	100
111.7	111.7	100
111.9	111.9	100
112.1	112.1	100
112.3	112.3	100
112.5	112.5	100
112.7	112.7	100
112.9	112.9	100
113.1	113.1	100
113.3	113.3	100
113.5	113.5	100
113.7	113.7	100
113.9	113.9	100
114.1	114.1	100
114.3	114.3	100
114.5	114.5	100
114.7	114.7	100
114.9	114.9	100
115.1	115.1	100
115.3	115.3	100
115.5	115.5	100
115.7	115.7	100
115.9	115.9	100
116.1	116.1	100
116.3	116.3	100
116.5	116.5	100
116.7	116.7	100
116.9	116.9	100
117.1	117.1	100
117.3	117.3	100
117.5	117.5	100
117.7	117.7	100
117.9	117.9	100
118.1	118.1	100
118.3	118.3	100
118.5	118.5	100
118.7	118.7	100
118.9	118.9	100
119.1	119.1	100
119.3	119.3	100
119.5	119.5	100
119.7	119.7	100
119.9	119.9	100
120.1	120.1	100
120.3	120.3	100
120.5	120.5	100
120.7	120.7	100
120.9	120.9	100
121.1	121.1	100
121.3	121.3	100
121.5	121.5	100
121.7	121.7	100
121.9	121.9	100
122.1	122.1	100
122.3	122.3	100
122.5	122.5	100
122.7	122.7	100
122.9	122.9	100
123.1	123.1	100
123.3	123.3	100
123.5	123.5	100
123.7	123.7	100
123.9	123.9	100
124.1	124.1	100
124.3	124.3	100
124.5	124.5	100
124.7	124.7	100
124.9	124.9	100
125.1	125.1	100
125.3	125.3	100
125.5	125.5	100
125.7	125.7	100
125.9	125.9	100
126.1	126.1	100
126.3	126.3	100
126.5	126.5	100
126.7	126.7	100
126.9	126.9	100
127.1	127.1	100
127.3	127.3	100
127.5	127.5	100
127.7	127.7	100
127.9	127.9	100
128.1	128.1	100
128.3	128.3	100
128.5	128.5	100
128.7	128.7	100
128.9	128.9	100
129.1	129.1	100
129.3	129.3	100
129.5	129.5	100
129.7	129.7	100
129.9	129.9	100
130.1	130.1	100
130.3	130.3	100
130.5	130.5	100
130.7	130.7	100
130.9	130.9	100
131.1	131.1	100
131.3	131.3	100
131.5	131.5	100
131.7	131.7	100
131.9	131.9	100
132.1	132.1	100
132.3	132.3	100
132.5	132.5	100
132.7	132.7	100
132.9	132.9	100
133.1	133.1	100
133.3	133.3	100
133.5	133.5	100
133.7	133.7	100
133.9	133.9	100
134.1	134.1	100
134.3	134.3	100
134.5	134.5	100
134.7	134.7	100
134.9	134.9	100
135.1	135.1	100
135.3	135.3	100
135.5	135.5	100
135.7	135.7	100
135.9	135.9	100
136.1	136.1	100
136.3	136.3	100
136.5	136.5	100
136.7	136.7	100
136.9	136.9	100
137.1	137.1	100
137.3	137.3	100
137.5	137.5	100
137.7	137.7	100
137.9	137.9	100
138.1	138.1	100
138.3	138.3	100
138.5	138.5	100
138.7	138.7	100
138.9	138.9	100
139.1	139.1	100
139.3	139.3	100
139.5	139.5	100
139.7	139.7	100
139.9	139.9	100
140.1	140.1	100
140.3	140.3	100
140.5	140.5	100
140.7	140.7	100
140.9	140.9	100
141.1	141.1	100
141.3	141.3	100
141.5	141.5	100
141.7	141.7	100
141.9	141.9	100
142.1	142.1	100
142.3	142.3	100
142.5	142.5	100
142.7	142.7	100
142.9	142.9	100
143.1	143.1	100
143.3	143.3	100
143.5	143.5	100
143.7	143.7	100
143.9	143.9	100
144.1	144.1	100
144.3	144.3	100
144.5	144.5	100
144.7	144.7	100
144.9	144.9	100
145.1	145.1	100
145.3	145.3	100
145.5	145.5	100
145.7	145.7	100
145.9	145.9	100
146.1	146.1	100
146.3	146.3	100
146.5	146.5	100
146.7	146.7	100
146.9	146.9	100
147.1	147.1	100
147.3	147.3	100
147.5	147.5	100
147.7	147.7	100
147.9	147.9	100
148.1	148.1	100
148.3	148.3	100
148.5	148.5	100
148.7	148.7	100
148.9	148.9	100
149.1	149.1	100
149.3	149.3	100
149.5	149.5	100
149.7	149.7	100
149.9	149.9	100
150.1	150.1	100
150.3	150.3	100
150.5	150.5	100
150.7	150.7	100
150.9	150.9	100
151.1	151.1	100
151.3	151.3	100
151.5	151.5	100
151.7	151.7	100
151.9	151.9	100
152.1	152.1	100
152.3	152.3	100
152.5	152.5	100
152.7	152.7	100
152.9	152.9	100
153.1	153.1	100
153.3	153.3	100
153.5	153.5	100
153.7	153.7	100
153.9	153.9	100
154.1	154.1	100
154.3	154.3	100
154.5	154.5	100
154.7	154.7	100
154.9	154.9	100
155.1	155.1	100
155.3	155.3	100
155.5	155.5	100
155.7	155.7	100
155.9	155.9	100
156.1	156.1	100
156.3	156.3	100
156.5	156.5	100
156.7	156.7	100
156.9	156.9	100
157.1	157.1	100
157.3	157.3	100
157.5	157.5	100
157.7	157.7	100
157.9	157.9	100
158.1	158.1	100
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176.9	176.9	100
177.1	177.1	100
177.3	177.3	100
177.5	177.5	100
177.7	177.7	100
177.9	177.9	100
178.1	178.1	100

Table of Transformer and Distributing Stations (Continued)

Station	Capacity K.V.A.	Voltage
(13) Cookeville Transformer Station	5,000	110,000/13,200
	<u>1,050</u>	13,200/2,300
	6,050	
Brampton Distributing Station	900	13,200/4,000
Milton Distributing Station	750	13,200/2,200
Mimico Distributing Station	450	12,200/4,000
Port Credit Distributing Station	225	13,200/2,300
Streetsville Distributing Station	225	13,200/4,000
Weston Distributing Station	900	13,200/4,000
Woodbridge Distributing Station	225	13,200/4,000
(14) Kent Transformer Station	6,750	110,000/26,400
Blenheim Distributing Station	225	26,400/4,000
Bothwell Distributing Station	225	26,400/4,000
Brigden Distributing Station	75	26,400/575
Chatham Distributing Station (City Plant)	2,250	26,400/4,000
Dominion Sugar Co. (Wallaceburg) Distributing Station	400	26,400/130-65
Dresden Distributing Station	225	26,400/4,000
Forest Distributing Station	225	26,400/2,300
Oil Springs Distributing Station	150	26,400/4,000
Petrolia Distributing Station	900	26,400/4,000
Perch Distributing Station	450	26,400/4,000
Ridgetown Distributing Station	225	26,400/4,000
Sarnia Distributing Station	2,800	26,400/4,000
Thamesville Distributing Station	225	26,400/4,000
Tilbury Distributing Station	300	26,400/4,000
Wallaceburg Distributing Station	(450)	26,400/4,000
	(450)	26,400/4,000
Watford Distributing Station	50	26,400/4,000
(15) Essex Transformer Station	10,000	110,000/26,400
Amherstburg Distributing Station	300	26,400/4,000
Canard River Distributing Station	25	26,400/230
Canadian Salt Co. Distributing Station	4,500	26,400/175
Cotton Distributing Station	25	26,400/230
Essex Distributing Station	150	26,400/2,300
Harrow Distributing Station	75	26,400/2,300
Kingsville Distributing Station	225	26,400/4,000
Leamington Distributing Station	225	26,400/4,000
(16) York Transformer Station	5,000	110,000/13,200
Etobicoke Distributing Station	(3,000)	13,200/2,300
	(1,500)	13,200/4,000

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112,000/12,000	1,000	
114,000/12,000	1,000	
116,000/12,000	1,000	
118,000/12,000	1,000	
120,000/12,000	1,000	
122,000/12,000	1,000	
124,000/12,000	1,000	
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494,000/12,000	1,000	
496,000/12,000	1,000	
498,000/12,000	1,000	
500,000/12,000	1,000	

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Table of Total Capacity of Niagara System

Station	Capacity K.V.A.
Total Capacity of Niagara System excluding Reserve	426,150
Niagara System Reserve Capacity	171,575
Total Capacity Niagara System including Reserve	597,725

The list includes all transformers installed or ordered for the Commission's stations as of October 31st, 1921. It includes spares, but does not include station service transformers, nor transformers owned by municipalities in municipal stations and by the Commission's customers.

The main step-up transformer station of the Queenston-Chippawa plant might properly be included here and also the transformer stations of the Toronto Power Company. These at present are as follows:

Queenston Transformer Station	225,000 K.V.A.	12,000/110,000 volts
Toronto Power Company Station	50,000 K.V.A.	12,000/60,000 volts.

Local Distributing Stations.

With the exception of the rural lines already mentioned, there are no municipalities on the Niagara System in which the Hydro-Electric Power Commission of Ontario distributes power retail to consumers. The Commission acts as wholesale distributor, and in all the municipalities the electricity is distributed by the municipality itself or by the local commissions in the municipalities. The accounting for all of the municipalities of the Niagara System is

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Account	Amount
100,000	100,000
100,000	100,000
100,000	100,000

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1960-1961
1962-1963

First, the accounting for all of the municipalities of the Virginia system is

under the direct control of the Hydro-Electric Power Commission, and we understand that it is being done in accordance with the standard accounting system of the Hydro-Electric Power Commission. The details for the various municipalities are given in the Annual Reports of the Hydro-Electric Power Commission.

Niagara Rural Lines.

The Niagara Rural Lines, which consist of primary or main lines, were constructed by the Hydro-Electric Power Commission of Ontario in order to provide electrical energy to rural consumers adjacent to certain municipalities in the Niagara System, and the delivery of power commenced in the fiscal year ending October 31st, 1913. The majority of these rural lines are operated by municipalities and townships, which collect the revenue and maintain the lines, paying the Commission for the power supplied and for the interest and sinking fund provisions based upon the capital invested in the lines. These rural lines will apparently become the property of the townships operating them, when the accumulated sinking fund payments are sufficient to repay to the Commission the investment in the lines. A list of thirty-three municipalities and townships operating rural lines is given in Exhibit VIII of the Price, Waterhouse & Co. report on the Niagara System. The remaining rural lines are directly operated by the Commission, which collects from the customers by the charge for power, the operating costs, the rural lines maintenance and operating expenses, the reserves for renewals, and the interest and sinking fund provisions on the cost of the lines which at October 31st, 1921, amounted to \$27,067.50. At that date the last named rural lines supplied the following eight customers:

100-443887-100

[illegible]

Brady and Raymond,
William Fullen,
Innes, Kurn and Longworth,
W. G. Bailey,

Port Dalhousie,
South Dorchester Township,
West Flamboro Township,
Copetown District.

The lines operated by the Commission at its own risk showed a small deficit each year for the four years ending October 31st, 1921, although from the commencement of operations to October 31st, 1921, the operation of these lines has resulted in a surplus of \$1,590.47.

Characteristics of the Market.

Population Served and Percentage of Consumers to Population.

The district served by the Niagara System is both urban and rural, containing a number of large cities and many small cities and towns. The principal places are - Toronto with a population of 512,812; Hamilton, 114,766; London, 59,281; Windsor, 37,120; and Brantford, with 32,786. There are also ten cities with populations between 10,000 and 25,000, seven towns with populations between 5,000 and 10,000, forty-eight towns with populations between 1,000 and 5,000, together with a large number of villages and extensive rural lines. The combined population of the municipalities served by the Niagara System was approximately 1,105,500 in 1921.

The tables following show the growth in the population supplied by the Niagara System, the increase in the domestic light and commercial light consumers, and the power users with the average individual consumption for the

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The first group of the population at the time of the census was small. It was made up of the few people who had remained in the area since the war. The second group was made up of the people who had returned to the area after the war. The third group was made up of the people who had been born in the area since the war. The fourth group was made up of the people who had been born in the area before the war. The fifth group was made up of the people who had been born in the area before the war.

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calendar years 1918 to 1921 inclusive. The figures for these tables and curves were obtained or deduced from the Annual Reports of the Hydro-Electric Power Commission. The percentage of consumers to population is comparatively low on account of the fact that in the two largest cities, Toronto and Hamilton, there are well-established, privately owned electric distributing companies which compete with the Hydro-Electric Power Commission. Competition in Toronto has, however, recently been eliminated since the Hydro-Electric Power Commission has taken over the Toronto Power Company. It must also be noted that The Ontario Power Company, the Toronto Power Company and the Canadian Niagara Power Company supply under contract large amounts of power to private companies in the district supplied by the Niagara System, but this power is not included in the tables below:

Table of Market Statistics

Year	Population of Municipalities Supplied by Niagara System	Total Consumers	Per Cent. Consumers to Population
1918	973,333	146,421	15.3
1919	1,054,430	174,989	16.6
1920	1,063,479	200,326	18.9
1921	1,105,493	218,382	19.7

Table of Power Consumed

Year	Kilowatt-hours		Consumers		Power	
	Domestic Light	Commercial Light	Domestic Light	Commercial Light	H.P.	Consumers
1918	50,730,176	28,131,173	118,744	23,144	119,016	4,693
1919	56,553,072	37,456,122	129,866	26,437	130,092	5,465
1920	83,455,116	48,032,608	161,060	28,605	153,212	5,993
1921	105,570,638	56,494,429	175,614	29,916	167,408	6,150

enclosed please find the 1918 statement. The figures for 1918 and 1917 were obtained as follows from the annual report of the 1918-1919 year. The statement of accounts is prepared in conformity with the amount of the bill in the two latest years, 1917 and 1918, and was determined, naturally, upon the basis of the statement of which, with the 1918-1919 year statement, comparison is made. The statement, naturally, was obtained from the 1918-1919 year statement and from the 1917 year statement. It was also noted that the same items, namely, the 1917 year statement and the 1918 year statement, were supplied under similar large amounts of power to produce compared in the rates applied by the 1918 year statement and the 1917 year statement.

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Very truly yours,

STATE OF NEW YORK

Year	Supplied by Electric System	Consumption	Year	Supplied by Electric System	Consumption
1918	1,000,000	1,000,000	1917	1,000,000	1,000,000
1919	1,000,000	1,000,000	1918	1,000,000	1,000,000
1920	1,000,000	1,000,000	1919	1,000,000	1,000,000
1921	1,000,000	1,000,000	1920	1,000,000	1,000,000

STATE OF NEW YORK

Year	Consumption	Consumption	Consumption	Consumption	Consumption
1918	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
1919	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
1920	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
1921	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000

Table of Power Consumed per Consumer

Year	Kilowatt-hours		Horse-power per Power Consumer
	Domestic Light	Commercial Light	
1918	427	1,217	25.4
1919	405	1,414	23.8
1920	518	1,349	26.7
1921	598	1,818	27.2

Growth of Market and Ultimate Source of Power Supply.

Since the commencement of operations in 1911, the growth of the Niagara System has been rapid. The three curves on page 40 showing horse-power billed to municipalities and to companies, and the total horse-power billed to the Niagara System, show the growth clearly. The demand has more than doubled in the last six years. There was a very slight drop in 1919, but the recovery from the depression following the signing of the Armistice has been worthy of note.

Capital Costs.General.

The figures of capital costs given in the table below and plotted diagrammatically, and shown on the sheet of curves included as page 36 were obtained from page 7 of the report of Messrs. Price, Waterhouse & Co. to the Hydro-Electric Inquiry Commission under date of October 9th, 1922, except for the years 1912 to 1916 inclusive, which were obtained from the Annual Reports of

Sampling temperature (°C)	Sampling rate (L/min)		Flow (L/min)
	Inlet (L/min)	Outlet (L/min)	
6.0	725.1	712	913.1
7.0	818.1	806	913.1
7.5	756.1	742	913.1
8.0	748.1	736	913.1

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[illegible]

THE NATIONAL GUARDIAN, LONDON, SATURDAY, 11th JANUARY 1902.

the Hydro-Electric Power Commission. No capital costs for generating stations are included.

Table of Progressive Capital Costs

Capital Assets	1912	As at Year Ending October 31st.			
		1913	1914	1915	1916
Transmission Lines	\$2,798,210	\$3,509,526	\$5,505,047	\$6,370,462	\$6,748,650
Transformer and Distributing Stations	1,360,611	1,645,450	2,339,246	2,739,320	3,063,390
Rural Lines		35,883	159,382	275,118	324,158
Totals	\$4,158,821	\$5,190,859	\$8,003,675	\$9,384,900	\$10,136,208

Table of Progressive Capital Costs (Continued)

Capital Assets	1917	As at Year Ending October 31st.			
		1918	1919	1920	1921
Transmission Lines	\$7,702,413	\$8,009,097	\$8,042,416	\$8,197,520	\$8,790,635
Transformer and Dis- tributing Stations	4,003,676	5,293,073	5,790,871	6,295,833	6,533,621
Rural Lines	453,445	481,298	473,685	475,656	476,426
Totals	\$12,159,532	\$13,783,468	\$14,306,972	\$14,969,019	\$17,800,682

It will be noted that the total of the capital costs to the end of 1921, amounting to approximately eighteen million dollars, is divisible roughly into eight million, eight hundred thousand dollars for transmission lines, eight million, five hundred thousand dollars for transformer and distributing stations, and less than five hundred thousand dollars for rural lines. The fact that the capital cost of transformer and distributing stations is very nearly equal to the cost for transmission lines is an indication of the density of the load throughout the System.

1930-1931

The following is a summary of the results of the investigation conducted during the year 1930-1931.

The results are as follows:

Table of the results of the investigation

Category	1930	1931	1932	1933	1934
General results	1,000,000	1,200,000	1,500,000	1,800,000	2,000,000
Particular results	500,000	600,000	700,000	800,000	900,000
Results of the investigation	500,000	600,000	700,000	800,000	900,000

Table of the results of the investigation

Category	1930	1931	1932	1933	1934
General results	1,000,000	1,200,000	1,500,000	1,800,000	2,000,000
Particular results	500,000	600,000	700,000	800,000	900,000
Results of the investigation	500,000	600,000	700,000	800,000	900,000

It will be noted that the results of the investigation are as follows:

The results of the investigation are as follows:

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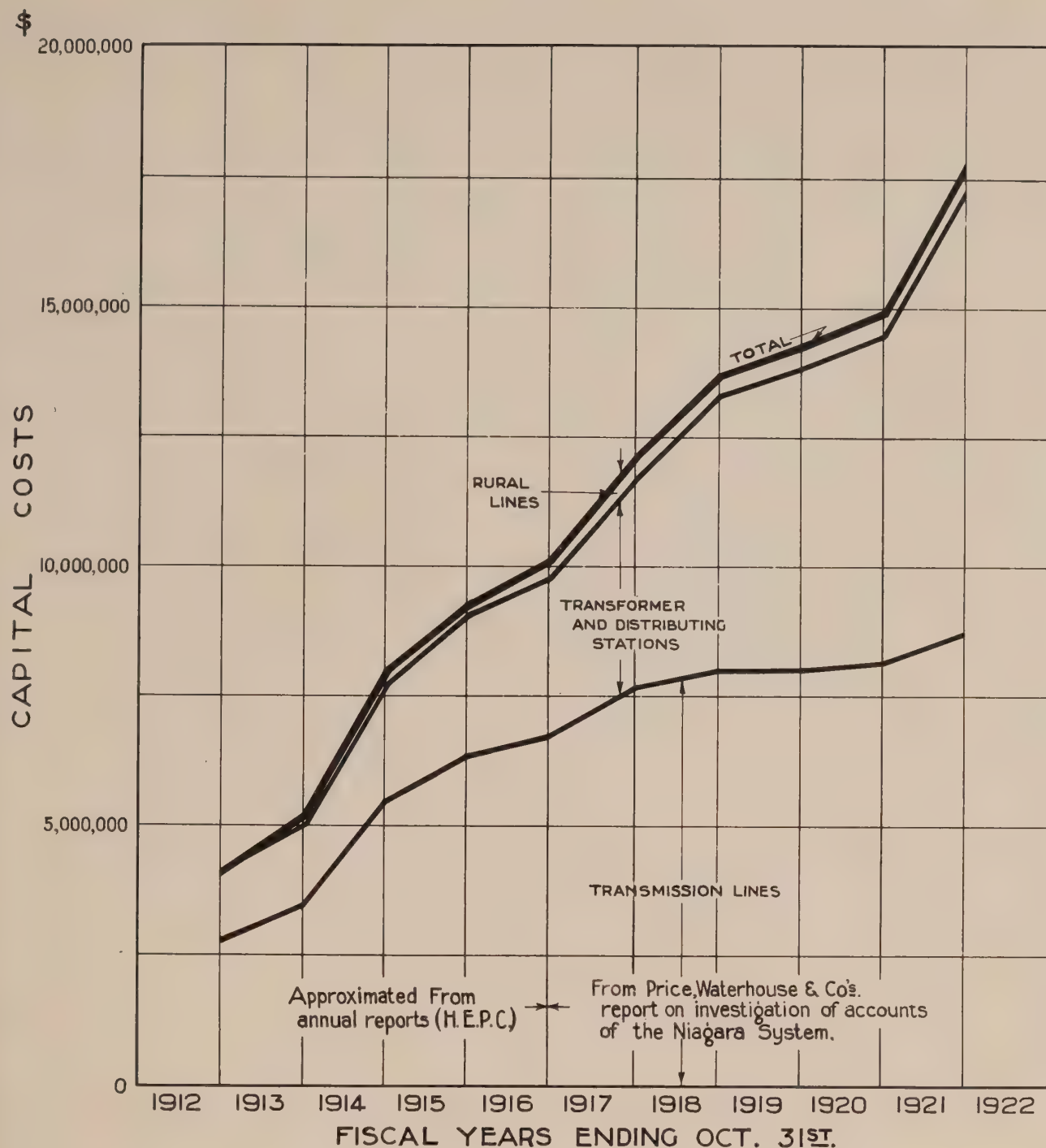
The results of the investigation are as follows:

The results of the investigation are as follows:

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HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

NIAGARA SYSTEM

PROGRESSIVE CAPITAL COSTS

Toronto, June 15th, 1923. Made by *WJF* Checked by *WJF*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

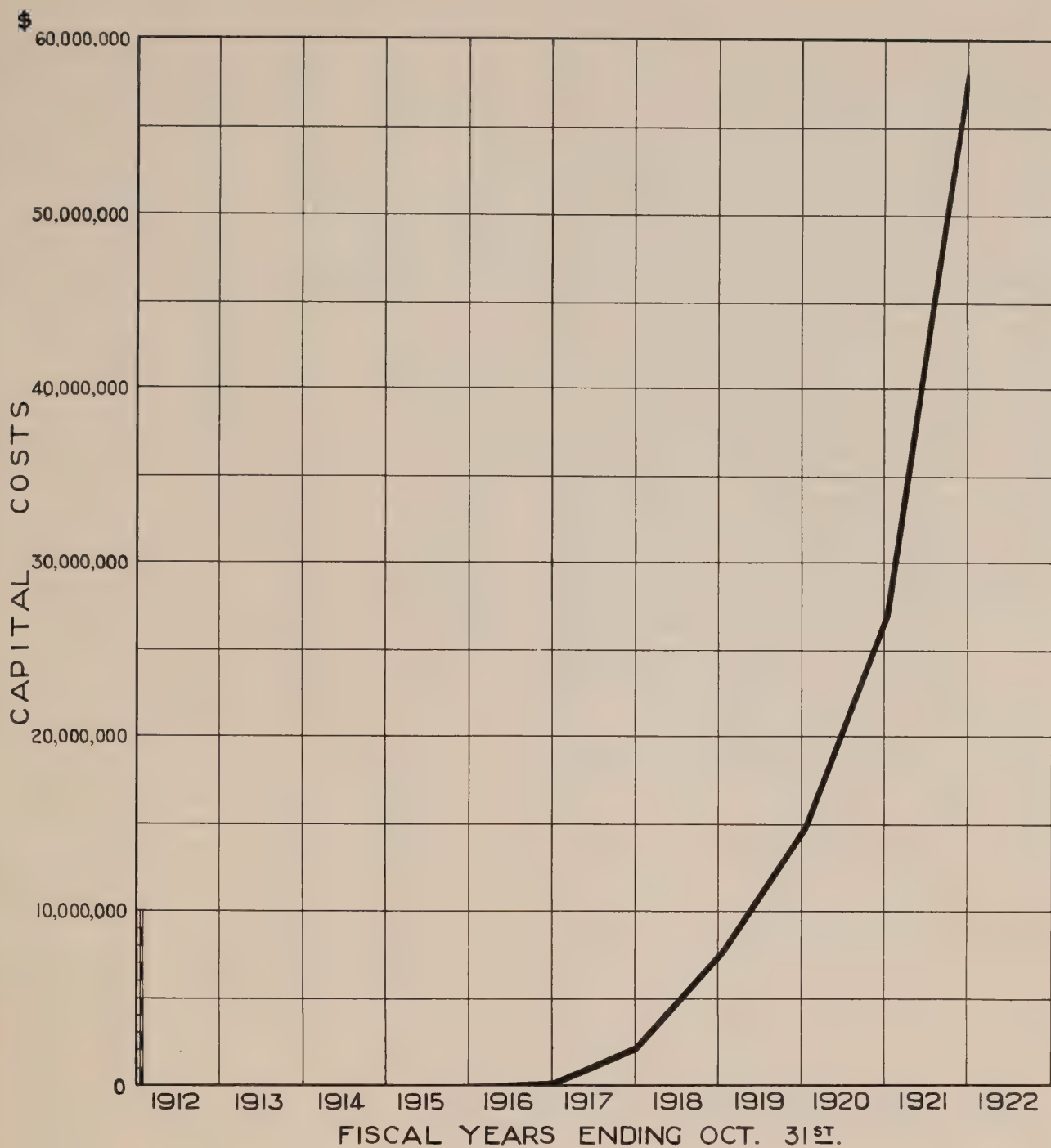
The following table and the sheet of curves included as page 38 show the capital cost of the Queenston-Chippawa Development as obtained from the Annual Reports of the Hydro-Electric Power Commission. It amounted to \$58,018,367 at October 31st, 1921.

Table of Progressive Capital Costs - Queenston-Chippawa Power Development

CAPITAL COSTS	Fiscal Year Ending	Amount
	October 31st, 1916	\$ 33,513
	October 31st, 1917	2,376,688
	October 31st, 1918	7,550,971
	October 31st, 1919	14,713,970
	October 31st, 1920	26,846,896
	October 31st, 1921	58,018,367
	March 31st, 1922	62,102,623

A summary of the estimates of the Hydro-Electric Power Commission for additional funds required as at October 31st, 1921, for the Niagara System, Niagara Rural Lines, and Queenston-Chippawa Development, for the fiscal years ending October 31st, 1922, and 1923, are as follows:

	Year Ending October 31st,	
	1922	1923
For the Niagara System, Lines and Stations	\$4,712,000	\$2,795,000
For the Niagara Rural Lines	1,000,000	750,000
For the Queenston-Chippawa Development	8,000,000	1,300,000



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
NIAGARA SYSTEM
PROGRESSIVE CAPITAL COSTS
(CHIPPAWA DEVELOPMENT)
Toronto, June 15th, 1923. Made by *WJF* Checked by *WJF*
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Power Data.

The following table and the diagrams included as page 40 have been prepared to show the characteristics of the Niagara System in terms of horse-power:

Table of Horse-power Developed, Billed, etc.

Horse-power	Fiscal Years Ending October 31st.			
	1911	1912	1913	1914
Purchased	7,948.3	20,619.9	36,334.2	51,677.6
Consumed Average				
Billed Total	6,832.3	21,419	37,165.1	50,752.3
Billed to Municipalities	6,786.6	19,766	33,271.9	43,234.7
Billed to Companies	46.7	1,553	5,893.2	7,517.6
Average 12 Monthly Peaks	7,630	21,380	36,980	50,300
Maximum Yearly Peak	13,500	29,300	42,400	68,000

Horse-power	Fiscal Years Ending October 31st.			
	1915	1916	1917	1918
Purchased	79,877.3	105,229.8	132,054	137,642.6
Consumed Average				
Billed Total	79,115.4	109,583.3	142,328.8	156,828.8
Billed to Municipalities	58,877.1	79,682.6	106,161.1	128,711
Billed to Companies	20,238.3	29,900.7	36,167.7	28,117.8
Average 12 Monthly Peaks	81,900	110,400	135,200	144,500
Maximum Yearly Peak	93,300	124,000	142,500	152,000

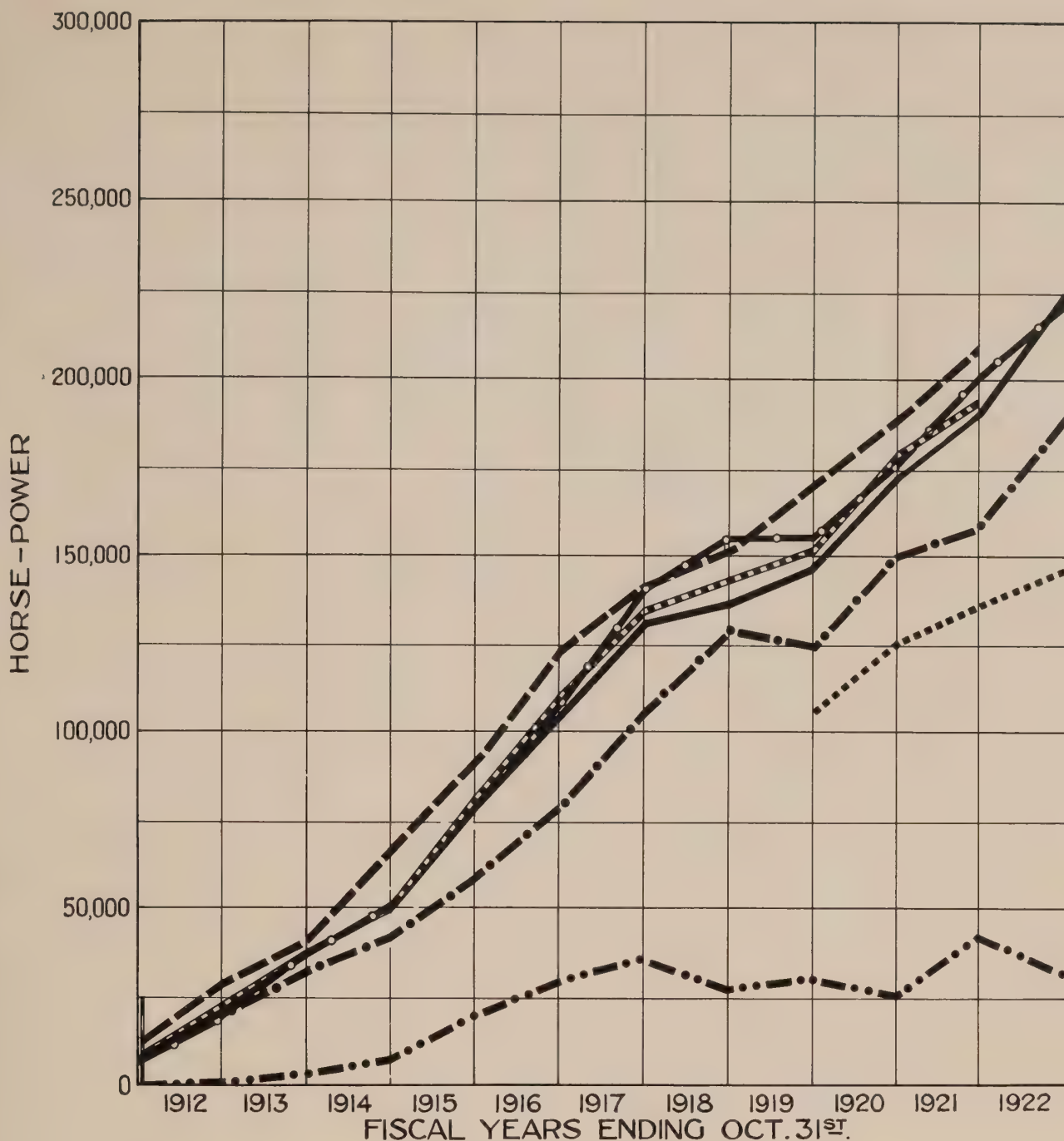
Horse-power	Fiscal Years Ending October 31st.			
	1919	1920	1921	1922
Purchased	148,030.6	172,912.8	191,572.9	225,701
Consumed Average	106,680	125,987	136,436	147,569
Billed Total	155,836.3	177,419.4	201,520.9	222,535.1
Billed to Municipalities	125,122.9	151,419.5	158,149.3	190,623
Billed to Companies	30,713.4	25,999.9	43,371.6	31,912.1
Average 12 Monthly Peaks	152,800	175,100	194,800	
Maximum Yearly Peak	172,000	189,000	209,000	

NIAGARA SYSTEM
HORSE-POWER DATA

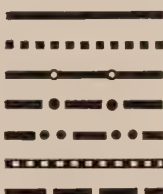
The following information was obtained from the records of the
Department of the Interior, Bureau of Land Management, and is
being furnished to you for your information.

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H. P. PURCHASED
 H. P., AVERAGE CONSUMED
 H. P., TOTAL BILLED
 H. P. BILLED TO MUNICIPALITIES
 H. P. BILLED TO COMPANIES
 H. P., AVERAGE OF 12 MONTHLY PEAKS
 H. P., MAXIMUM YEARLY PEAK



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

NIAGARA SYSTEM

HORSE-POWER DATA

Toronto, June 15th, 1923. Made by *WJF*, Checked by *WJF*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

It will be noted that there are seven different classes of horse-power shown in the table and on the diagrams. These may be explained as follows:

Purchased Horse-power.

All of the power used on the Niagara System has been purchased from The Ontario Power Company, from the Toronto Power Company and from other companies at Niagara Falls or from the Queenston - Chippawa Development. There is therefore no "developed" horse-power on the Niagara Distribution System proper, with the exception of the small Brindale plant on the Credit River.

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Average Horse-power Consumed.

The average horse-power consumed has been derived from the total number of kilowatt-hours given by the engineers of the Hydro-Electric Power Commission as being the total kilowatt-hours supplied to the Niagara System for the fiscal years ending October 31st, 1919 to 1922 inclusive. The derivation was made by dividing the total kilowatt-hours per annum by 8,760, being the number of hours in a year, and reducing to horse-power by dividing by the factor 0.746. The measurements of kilowatt-hours consumed were made at the Niagara Station, and therefore include the losses in the lines and in the transformer and distributing stations.

Billed Horse-power.

The curve of billed horse-power was plotted from data given by the

engineers and the accountants of the Hydro-Electric Power Commission.

A subdivision has been made between the horse-power sold to municipalities and that sold to private companies.

Average of Monthly Peaks, Horse-power.

The figures for the average of the twelve monthly peaks in horse-power were given by the engineers of the Hydro-Electric Power Commission.

Maximum Yearly Peak, Horse-power.

The figures for the maximum yearly peaks were also given by the engineers of the Commission and represent the maximum load on the System at any time during the year.

A study of these curves shows the very rapid and steady growth of the Niagara System. The yearly load factor as represented by the ratio of average horse-power consumed to total horse-power purchased is high, being of the order of 65 or 70 per cent.

Capital Costs per Horse-power Purchased.

The following table and the diagram included as page 44 indicate the fractional capital costs per horse-power purchased at different points of delivery, based on the figures showing the capital costs of the Niagara System including the Niagara Rural Lines, and the horse-power data given above. This

and the amount of the same shall be determined by the Board of Directors.

The Board of Directors may also cause the same to be paid to the stockholders.

and that sold to private companies.

and that sold to private companies.

Amount of Capital Stock Issued.

The Board of Directors may also cause the same to be paid to the stockholders.

and that sold to private companies.

and that sold to private companies.

Amount of Capital Stock Issued.

COPY

The Board of Directors may also cause the same to be paid to the stockholders.

and that sold to private companies.

and that sold to private companies.

A copy of this report shall be filed with the State of New York.

The Board of Directors may also cause the same to be paid to the stockholders.

and that sold to private companies.

and that sold to private companies.

and that sold to private companies.

and that sold to private companies.

Amount of Capital Stock Issued.

The Board of Directors may also cause the same to be paid to the stockholders.

and that sold to private companies.

and that sold to private companies.

and that sold to private companies.

\$ 250.00

sheet of curves, therefore, indicates the capital costs per horse-power purchased, with the spaces between adjacent curves indicating that portion of the total (delivered) capital cost per horse-power chargeable against each of the items of the table as follows:

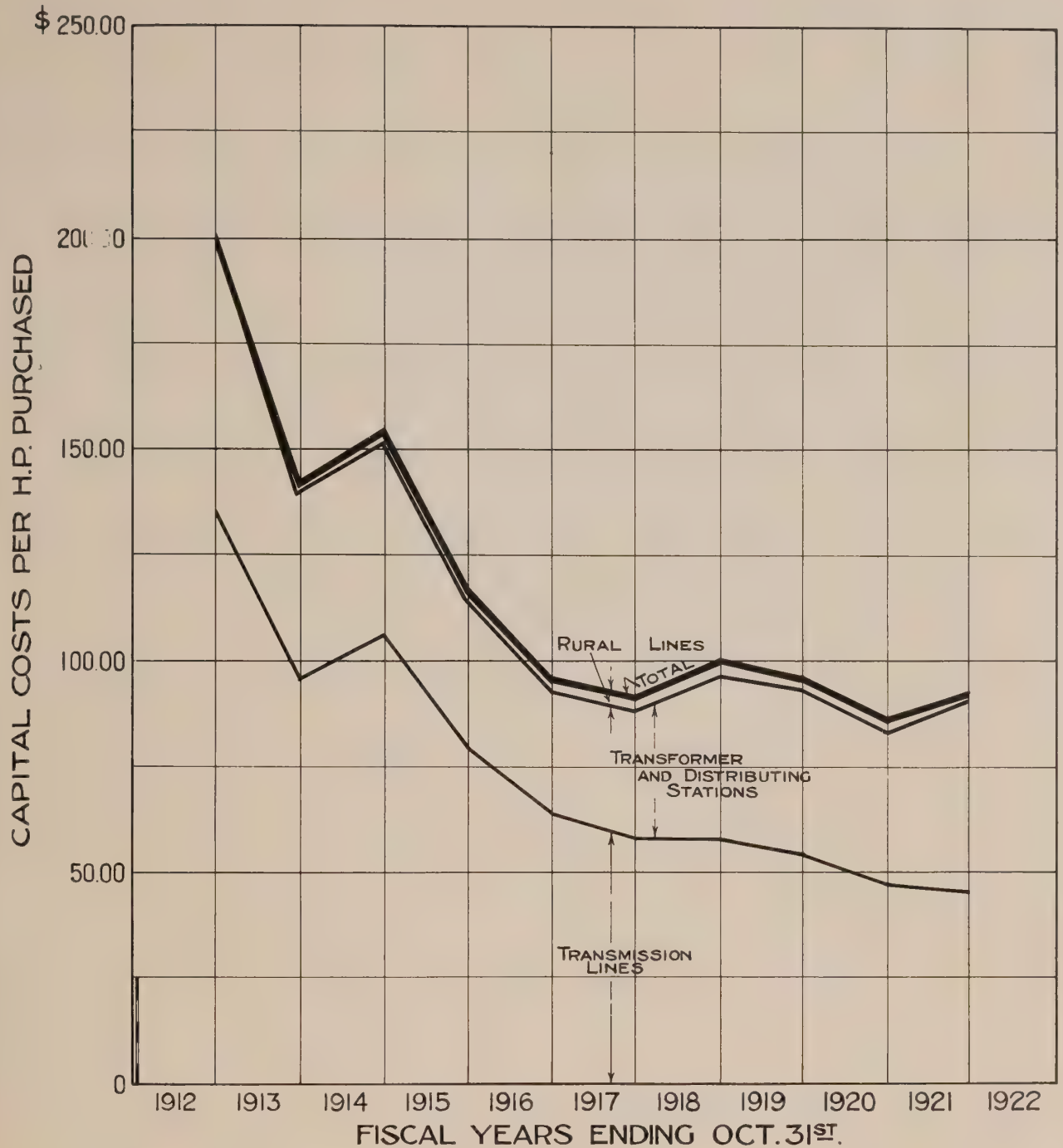
Table of Capital Costs per Horse-power Purchased

	Fiscal Year Ending October 31st.				
	1912	1913	1914	1915	1916
Transmission Lines	\$135.70	\$ 96.80	\$106.50	\$ 79.80	\$64.10
Transforming and Distributing Stations	66.00	45.80	45.80	34.30	29.10
Rural Lines	-	1.00	3.10	3.40	3.10
Totals	\$201.70	\$142.90	\$154.90	\$117.50	\$96.30

	Fiscal Year Ending October 31st.				
	1917	1918	1919	1920	1921
Transmission Lines	\$ 58.30	\$ 58.20	\$ 54.30	\$ 47.40	\$45.90
Transforming and Distributing Stations	30.30	38.50	39.10	36.40	44.50
Rural Lines	3.40	3.50	3.20	2.80	2.50
Totals	\$ 92.00	\$100.20	\$ 96.60	\$ 86.60	\$92.90

The capital cost per horse-power for transmission lines was high in the early years when the load was scattered but it is seen to fall off as the load density increases but probably will not decrease very much further. The capital cost per horse-power for transformer and distributing stations shows a decrease during the years 1915 to 1918 and in 1920 when the stations were loaded heavily, but would seem to have again returned approximately to the pre-war figure.

CAPITAL COSTS
PER H.P. PURCHASED



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

**NIAGARA SYSTEM
CAPITAL COSTS
PER H. P. PURCHASED**

Toronto, June 15th, 1923. Made by *W.F.*, Checked by *L.H.*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Total Revenues.

The table on page 46, giving the total revenues of the Niagara System, has been prepared by using the figures of Exhibit I, of the report on "Investigation of Accounts of Niagara System", dated October 9th, 1922, Hydro-Electric Inquiry Commission file No. 174-a. This applies to the years 1918 - 1921 inclusive. For the years from 1912 to 1917 inclusive the total revenues were taken from the Annual Reports of the Hydro-Electric Power Commission supplemented by later information supplied by the accountants of the Commission, giving the portions of the total revenues derived from municipalities and from companies. In 1917 adjustments were apparently made in the reserve for renewals account and certain amounts were credited to the various municipalities resulting in a reduction of revenue over these years up to and including 1917. For this reason the revenues lately given by the accountants of the Hydro-Electric Power Commission for these years do not agree with the totals given in the Annual Reports. The revenues have been subdivided into revenues from municipalities and revenues from companies by taking the revenues from companies from the figures of the accountants of the Hydro-Electric Power Commission and subtracting these amounts from the totals in the Annual Reports to obtain the revenues from municipalities.

From this information it may be deduced that the municipalities were charged with the cost of power and with the distribution thereof and with that portion of the fixed charges which pertained to the power supplied, while the power sold to companies was apparently charged with its proper proportion of operating expenses and fixed charges. For the period prior to October 31st,

... ..

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1917, Mr. Clarkson in his audit report states that a net profit of \$178,842.31 was earned by the System for power sold to corporations other than municipalities. Of this amount, the profit for the period ending October 31st, 1916, amounting to \$117,369.21, was applied to reduction of the maintenance costs to be met by municipal corporations under contract with the Commission. The profit for the fiscal year 1917, amounting to \$61,473.10, was applied to the contingency reserve. The profits for the years 1918 to 1921 have likewise been transferred to the contingency reserve. The table of revenues is as follows:

Table of Total Revenues for Various Classes of Customers

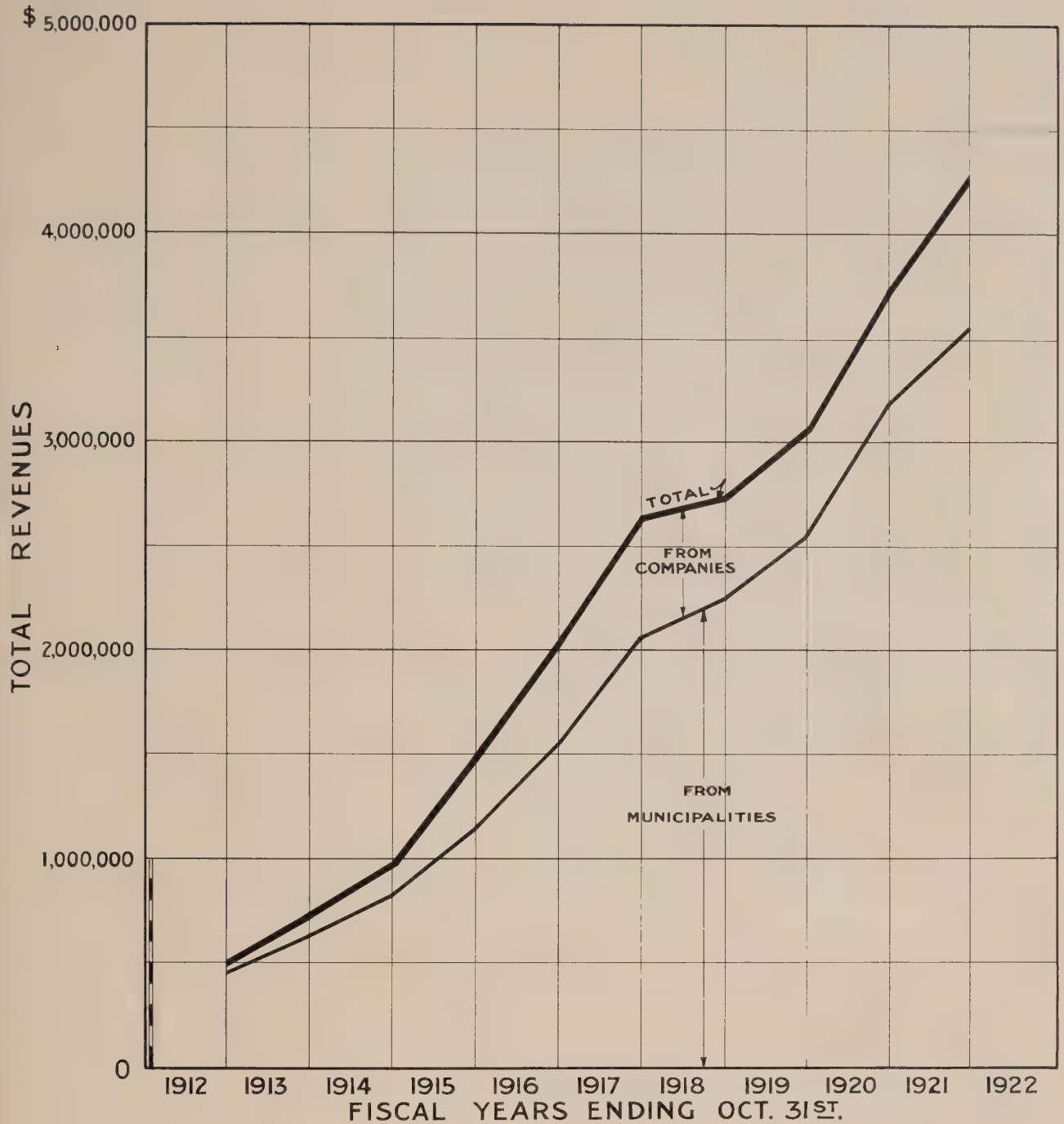
Source of Revenue	Fiscal Year Ending October 31st,				
	1912	1913	1914	1915	1916
Municipalities	\$464,830	\$637,398	\$824,238	\$1,157,214	\$1,549,763
Companies	46,972	113,793	170,916	349,967	489,029
Totals	\$511,802	\$751,191	\$994,254	\$1,506,281	\$2,038,792

Source of Revenue	Fiscal Year Ending October 31st,				
	1917	1918	1919	1920	1921
Municipalities	\$2,052,538	\$2,247,495	\$2,535,979	\$3,180,161	\$3,542,029
Companies	535,063	403,547	534,131	570,905	750,466
Totals	\$2,637,606	\$2,731,042	\$3,070,110	\$3,751,066	\$4,292,495

The curves on page 47 are plotted directly from this table.

Total Costs of Power.

The table on page 50 and the sheet of curves included as page 51 show the cost of power subdivided under various headings for the years 1912 to 1921



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

NIAGARA SYSTEM

TOTAL ANNUAL REVENUES

Toronto, June 15th, 1923. Made by *SRW*, Checked by *ELH*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

inclusive. The figures from 1918 to 1921 inclusive are made up from Exhibit I of the Price, Waterhouse & Co. report dated October 9th, 1922, while the figures for the years 1912 to 1917 were taken from the Annual Reports of the Hydro-Electric Power Commission.

The headings under which the various costs have been grouped are as follows:

Purchased Power.

All the power used on the Niagara System is purchased from the various generating plants at Niagara Falls or from the Queenston-Chippawa Power Development of the Hydro-Electric Power Commission and the purchased power, therefore, forms the largest single item in the cost of power to the municipalities and private companies supplied by this System.

Operating Costs.

Operating costs include the wages of linemen, station attendants, and so forth, supplies and all miscellaneous items usually grouped under this heading.

Maintenance.

Under maintenance have been placed all the items for labour and materials charged in the books of the Commission as against the individual portions of the transformer stations, transmission lines and distributing stations. These have been grouped together, from the individual figures in the Price, Waterhouse

& Co. report to make one item. For the years previous to 1918 the figures were obtained from the Annual Reports of the Hydro-Electric Power Commission.

Overhead and General Expense.

Under the heading of overhead and general expense are such items as salaries of officers and clerks at the head office, undistributed truck and automobile expense, handling maintenance stores, extraordinary maintenance, municipal auditing, engineering, municipal administration, estimating, insurance, executive expense, general expense, field office salaries and expenses, rent, laboratory operation, and so forth, all in accordance with Exhibit IB of the Price, Waterhouse & Co. report or taken from the Annual Reports.

Interest, Renewals, Sinking Fund and Contingencies.

The figures for interest include all interest charges shown for the capital invested in the System. The renewal account includes all items shown as chargeable against renewals in the same report, while the figures for sinking fund and for contingencies have been transferred directly from the report. In the figures for the earlier years taken from the Annual Reports the surplus, after deducting from the total receipts the disbursements for power purchased, operation, maintenance and general expense and interest, has been taken to represent the combined reserve for renewals, sinking fund and contingencies. No attempt has been made to further subdivide this item. It is stated in the Price, Waterhouse & Co. report that any surpluses or deficits resulting from the sale of

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The Director has reviewed all information received from the various sources involved in the project. The review indicates that there are no known or suspected connections between the individuals named in the report and the activities described therein. It is noted that the information provided by the various sources is inconsistent and unreliable. The Director has concluded that there is no basis for further investigation.

power to private companies in the years 1918 to 1921, inclusive, have been transferred to the reserve for contingencies, but these amounts have not been included in this item in the table following nor in the sheet of curves included as page 51.

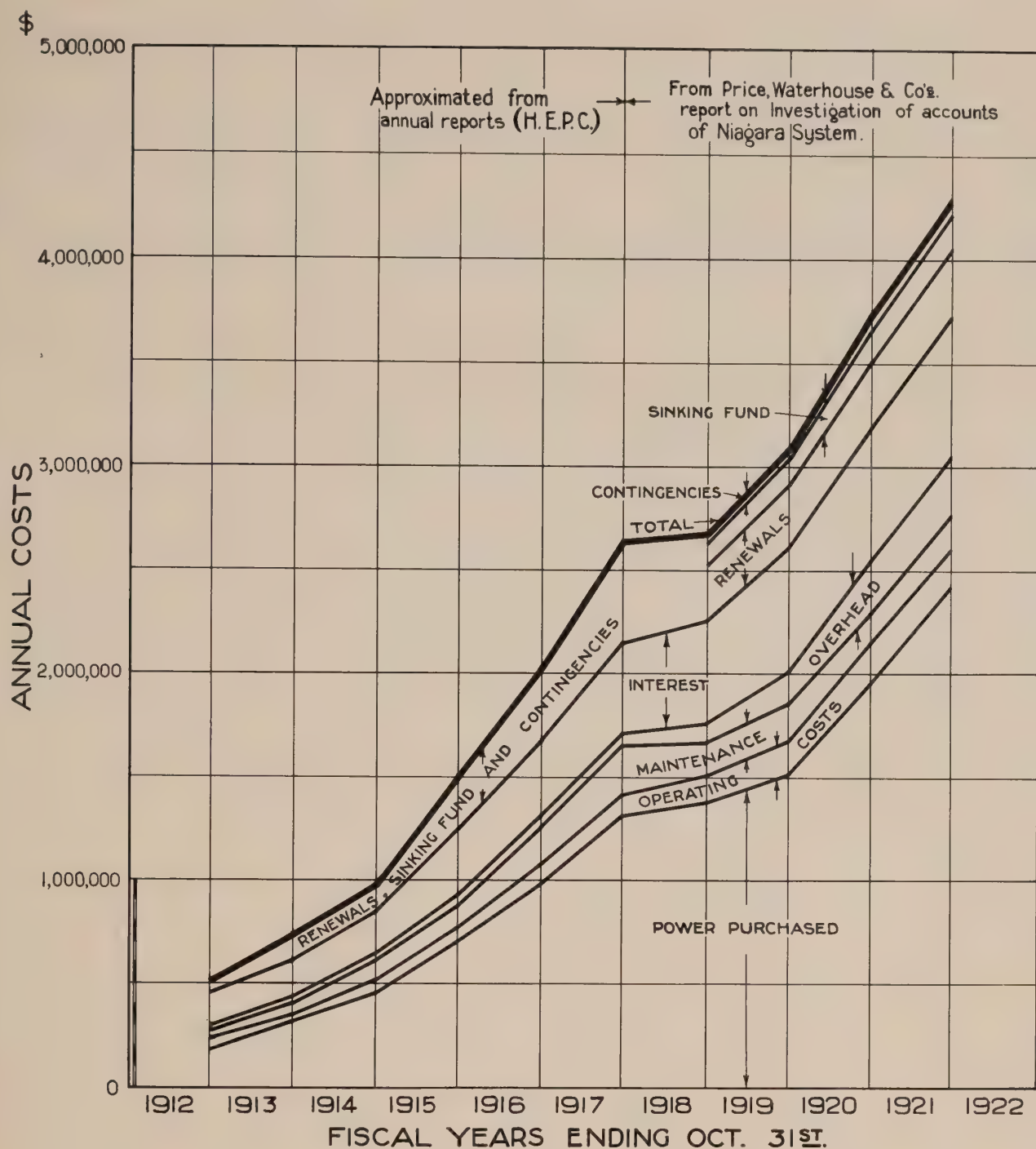
Table of Total Annual Costs

	Fiscal Years Ending October 31st.				
	1912	1913	1914	1915	1916
Power Purchased	\$ 192,864	\$ 327,007	\$ 465,098	\$ 718,896	\$ 997,257
Operation	49,916	42,193	53,008	60,087	92,522
Maintenance	38,979	41,837	95,847	112,297	180,962
Overhead	21,119	25,964	32,704	48,026	44,812
Interest	154,752	180,231	204,944	327,348	371,495
Renewals)				
Sinking Fund	) 55,166	133,939	142,353	239,629	351,834
Contingencies)				
Totals	\$ 511,802	\$ 751,191	\$ 994,254	\$1,506,281	\$2,038,792

	Fiscal Years Ending October 31st.				
	1917	1918	1919	1920	1921
Power Purchased	\$1,310,714	\$1,365,706	\$1,517,468	\$1,966,304	\$2,411,965
Operation	105,956	116,868	164,744	189,868	193,958
Maintenance	242,534	169,356	181,888	143,814	165,458
Overhead	58,922	101,594	159,282	251,416	296,663
Interest	432,841	431,312	583,734	644,859	668,319
Renewals	)	266,579	293,941	310,519	322,462
Sinking Fund	) 486,939	138,432	161,246	195,570	212,238
Contingencies	)	37,500	37,500	37,500	37,500
Totals	\$2,627,606	\$2,696,898	\$3,089,793	\$3,739,850	\$4,308,565

The sheet of curves included as page 51 is the direct plotting of the figures in the table above, with the spaces between adjacent curves indicating the amount chargeable against that particular item.

NIAGARA SYSTEM
SURVEYED ANNUAL COSTS



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

NIAGARA SYSTEM

SUBDIVIDED ANNUAL COSTS

Toronto, June 15th, 1923. Made by *WJF*, Checked by *L.H.*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Percentage Costs of Power.

The following table and the sheet of curves included as page 53 show the cost figures as percentages of the total cost of power per annum, and these are included as a comparison with other systems or similar properties:

Table of Total Annual Costs Subdivided by Percentages

	Fiscal Year Ending October 31st,									
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Power Purchased	37.6	43.5	46.80	47.70	48.93	49.68	51.47	49.07	52.57	55.96
Operation	9.6	5.6	5.53	3.99	4.54	4.02	4.29	5.34	5.08	4.51
Maintenance	7.6	5.6	9.64	7.47	8.88	9.17	8.27	5.38	3.84	3.84
Overhead	4.1	3.5	3.39	3.19	2.20	2.24	3.76	5.15	6.72	6.90
Interest	30.3	24.0	20.60	22.75	18.20	16.41	17.88	18.90	17.24	15.50
Renewals							9.88	9.53	8.31	7.49
Sinking Fund	10.8	17.3	14.34	15.90	17.25	18.48	5.13	4.90	5.24	4.93
Contingencies							1.39	1.22	1.30	0.87
Totals	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Analysis of Reserve Accounts.Renewals Account.

The table on page 55 and the sheet of curves included as page 56 show the amounts set aside as reserve for renewals as they existed at October 31st, 1921 on the books of the Hydro-Electric Power Commission. As shown on page 15 of the Price, Waterhouse & Co. report, the reserve for renewals for the Niagara System amounted, at October 31st, 1921, to \$2,222,365.90. It is stated therein that

WALTER J. FRANCIS & COMPANY
ANNUAL COSTS SUBDIVIDED
BY PERCENTAGES

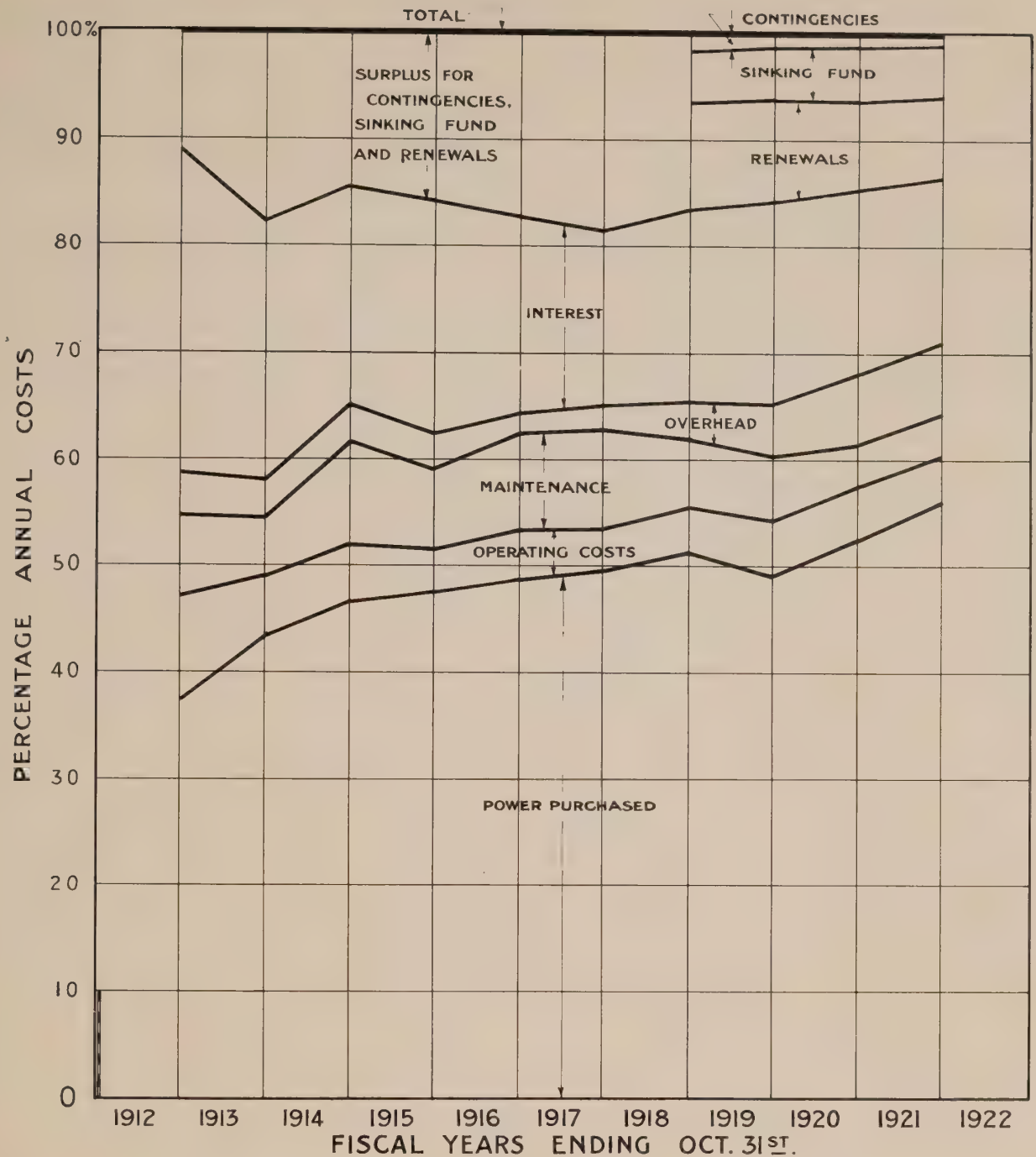
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	Table or Total Annual Costs Subsidized by Government
1960-1961	\$1,000,000
1961-1962	\$1,000,000
1962-1963	\$1,000,000
1963-1964	\$1,000,000
1964-1965	\$1,000,000
1965-1966	\$1,000,000
1966-1967	\$1,000,000
1967-1968	\$1,000,000
1968-1969	\$1,000,000
1969-1970	\$1,000,000
1970-1971	\$1,000,000
1971-1972	\$1,000,000
1972-1973	\$1,000,000
1973-1974	\$1,000,000
1974-1975	\$1,000,000
1975-1976	\$1,000,000
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2010-2011	\$1,000,000
2011-2012	\$1,000,000
2012-2013	\$1,000,000
2013-2014	\$1,000,000
2014-2015	\$1,000,000
2015-2016	\$1,000,000
2016-2017	\$1,000,000
2017-2018	\$1,000,000
2018-2019	\$1,000,000
2019-2020	\$1,000,000
2020-2021	\$1,000,000
2021-2022	\$1,000,000
2022-2023	\$1,000,000
2023-2024	\$1,000,000
2024-2025	\$1,000,000
2025-2026	\$1,000,000
2026-2027	\$1,000,000
2027-2028	\$1,000,000
2028-2029	\$1,000,000
2029-2030	\$1,000,000
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2031-2032	\$1,000,000
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2037-2038	\$1,000,000
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2064-2065	\$1,000,000
2065-2066	\$1,000,000
2066-2067	\$1,000,000
2067-2068	\$1,000,000
2068-2069	\$1,000,000
2069-2070	\$1,000,000
2070-2071	\$1,000,000
2071-2072	\$1,000,000
2072-2073	\$1,000,000
2073-2074	\$1,000,000
2074-2075	\$1,000,000
2075-2076	\$1,000,000
2076-2077	\$1,000,000
2077-2078	\$1,000,000
2078-2079	\$1,000,000
2079	

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959	2960	2961	2962	2963	2964	2965	2966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HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

NIAGARA SYSTEM ANNUAL COSTS SUBDIVIDED BY PERCENTAGES

Toronto, June 15th, 1923. Made by S.P.W. Checked by L.H.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

additions to the reserve for renewals on the Niagara System are provided through including, on a sinking fund basis in the cost of power each year, an amount equivalent to 2-1/2 per cent. on the capital investment of the System, exclusive of right-of-way. Interest at 4 per cent. on the credit balance in the account is added at the close of the preceding year. Charges against the reserve consist of expenditures on account of renewals, replacements, and so forth.

This method of providing additions to the reserve, known as the sinking fund basis, is equivalent to a renewal rate of approximately 4 per cent. per annum on the so-called "straight-line-basis", that is to say, while the amount of the annual amounts under the sinking fund method increase each year through interest accumulations and those under the straight line method remain constant, the amounts accumulated by either method would be approximately the same at the end of a given period, in this case 25 years.

The annual rate of 2-1/2 per cent. for renewals was determined in 1917, on the basis of a re-classification of the properties of the System as at October 31st, 1916, made by the Engineering Department of the Commission. This re-classification showed the estimated life, residual value, and so forth, as set forth in Exhibit IV of the report of Messrs. Price, Waterhouse & Co. on the Niagara System, dated October 9th, 1922. This rate has continued in force to October 31st, 1921, and the reserve as constituted at that date has been computed upon the same basis from the beginning of operations in November, 1911. In view of the possibility of the conditions varying, consideration should be given to the revision of the rates when the necessity arises.

Table of Reserve for Renewals

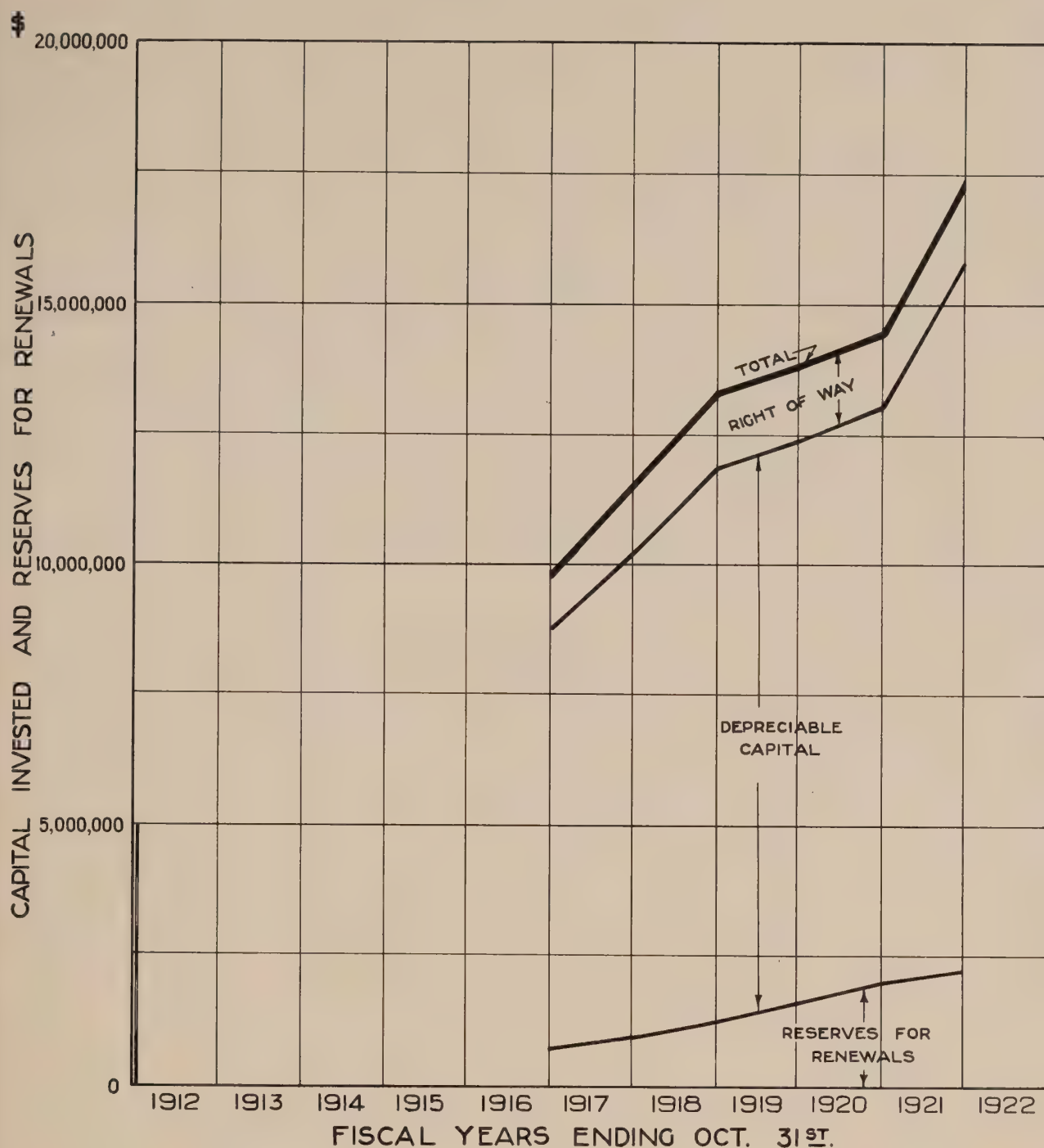
	Reserve	Interest at 4 Per Cent.	Together
Period 1912 to October 31st, 1916	\$ 684,368.90	\$ 42,993.63	\$ 727,362.53
Year Ending October 31st:			
1917	221,543.00	29,094.60	250,637.60
1918	266,579.32	39,245.52	305,824.84
1919	293,940.60	51,428.28	345,368.88
1920	310,519.12	65,205.39	375,724.51
1921	322,462.26	80,234.41	402,696.67
Together	\$2,099,413.20	\$308,201.83	\$2,407,615.03
Less Miscellaneous Deductions (net)			185,249.13
Total at October 31st, 1921			\$2,222,365.90

Table of Total Capital and Depreciable Capital and Reserves for Renewals

	1916	1917	As at October 31st,		1920	1921
			1918	1919		
Total Capital						
Invested	\$9,812,040	11,528,830	15,302,170	15,833,287	14,493,353	17,324,256
Right-of-way	1,041,287	1,324,325	1,324,040	1,459,813	1,482,884	1,511,125
Depreciable Capital	8,770,753	10,204,505	11,879,130	12,373,474	13,010,469	15,813,131
Reserve for Renewals	727,363	978,000	1,283,825	1,629,194	2,004,918	2,222,366

Note: No generating plants are included in the above table. The audited figures are not yet available for 1922.

The adequacy of the renewals account depends upon the method of its application considered in relation to the total capital invested. It is understood that it is the practice of the Hydro-Electric Power Commission to spend sufficient money on maintenance account each year to keep each and every portion of



HYDRO-ELECTRIC INQUIRY COMMISSION
 W. D. GREGORY, CHAIRMAN
 ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
NIAGARA SYSTEM
RESERVES FOR RENEWALS

Toronto, June 15th, 1923. Made by *WJF*, Checked by *WJF*
 WALTER J. FRANCIS & COMPANY
 CONSULTING ENGINEERS

the System in a condition to operate in accordance with the requirements of economical production, which, it is stated, is about 75 per cent. as good as its original new condition. If this be so, the consideration of the renewal account might well be studied in connection with and applied to the renewal of only 25 per cent. of the depreciable capital concerned.

The total invested capital in the Niagara distribution system proper at October 31st, 1922, is on the order of twenty-one or twenty-two millions of dollars of which the depreciable amount is probably between eighteen millions and twenty millions. Considering all the factors, the portion of depreciable capital to be covered by a renewal account might be considered as between five million dollars and six million dollars after making allowance for the portion said to be provided for in the maintenance account as above mentioned. As the Niagara System was commenced twelve or thirteen years ago with a comparatively small capital, and as the invested capital has been steadily increasing year by year, it would appear that the total amount in the reserve account, which now stands at a figure between two and three million dollars, is sufficiently large to serve the required purpose.

Reserve for Sinking Fund.

The reserve for sinking fund in respect to the capital cost of the Niagara System amounted to \$957,717.89 at October 31st, 1921, as shown on page 17 of the Price, Waterhouse & Co. report on the Niagara System. Of this total amount \$670,525.56 was credited as being applicable to municipalities and \$287,192.33 as being applicable to companies.

The system is a simplified form of the system used in the
 commercial practice, which, it is stated, is used in the
 the original was simplified. It is not, however, as the
 amount which will be added in connection with the
 at only 25 per cent of the expenditure required.

The total interest required for the system described above is
 100,000,000. It is on the basis of the system of
 which is which the expenditure would be 100,000,000. It is
 and twenty million. Excluding all the other, the system is
 capital is to be added to a system of capital of 100,000,000. It
 million dollars and six million dollars of the capital of the system
 will be provided for in the system of capital of 100,000,000. It
 system of capital of 100,000,000. It is a system of capital of
 will capital, and on the interest capital has been working for
 by year, it would require that the total capital is the system of capital
 the system of capital between the two systems of capital is
 large to serve the required purpose.

THE SYSTEM OF CAPITAL

The system of capital is based on the capital of the system
 system of capital of 100,000,000. It is a system of capital of
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 as a system of capital of 100,000,000.

The basis for ascertaining the amount of the reserve for sinking fund each year is the capital cost of the transformer stations and transmission lines, and so forth, completed and in operation. An annual sum is set aside which would be sufficient to build up in thirty years, with interest compounded at 4 per cent. per annum, an amount equal to the capital invested. The sum required is equivalent to an annual reserve of 1.3 per cent. of the capital invested, proper allowance being made for units of the plant which have been in operation less than a year.

The capital investment of the respective sections of the lines and stations is distributed to the municipalities, and others receiving power therefrom, in the proportion that the horse-power furnished each customer bears to the aggregate horse-power furnished all customers on these sections of the lines.

The portion of the reserve so determined as applicable to municipalities in operation for a period of six years or longer is included each fiscal year in the cost of power supplied to the respective municipalities.

As permitted under the Act, the collection of the sinking fund was deferred for a period of five years in the case of all municipalities on the Niagara System.

Reserve for Contingencies.

The reserve for contingencies was established by the Commission to provide for special losses and for expenses not arising at regular intervals and not wholly applicable to the period in which they occurred.

The provision for contingencies, in respect of the Niagara System, is made up of:

- (a) An annual charge of \$37,500, included as part of the cost of power delivered to municipalities and to sundry customers,
- (b) The net profits resulting from the sale of power to sundry customers,
- (c) Profit from sales of miscellaneous materials, and so forth, and
- (d) Interest at four per cent. per annum on the monthly balances.

The following is a summary of the additions to the reserve and expenditure charged against the reserve for the five years ending October 31st, 1921:

Amounts included as part of the cost of power delivered -

To municipalities	\$151,685.07	
To sundry customers	35,674.25	\$187,359.32
Net profit from sale of power to sundry companies		78,932.96
Net profit on sale of aluminum cable, sundry equipment, etc.		7,645.80
Miscellaneous material recovered, previously charged to construction, operations, etc.		22,097.90
Interest at four per cent. per annum		<u>9,314.90</u>
Total credits		\$305,350.88

The losses of a contingent character incurred in the last four years were -

Year ending October 31st, 1918	\$135,140.70	
1919	70,840.96	
1920	43,576.64	
1921	<u>30,917.57</u>	\$280,475.87
Balance as at October 31st, 1921		<u>\$ 24,875.01</u>

It will be noted that this balance is much less than the average of the contingent expenditures for the last four years, and consideration should be given to the provision of a larger reserve for contingencies.

The information regarding the reserve for contingencies was obtained from pages 19 to 21 and from Exhibit VI of the report of Messrs. Price, Waterhouse & Co. on the Niagara System and further details may be found there.

Discussion of Deficits and Surpluses.

The various municipalities included in the Niagara System are apparently being billed with power at cost, and there is no deficit or surplus account. Charges or credits giving effect to adjustments are apparently passed directly to the accounts of the respective municipalities concerned, and not through the operating account of the period in which they are found.

Profit or loss since October 31st, 1917, resulting from sales of power to private companies, has been transferred to the reserve for contingencies.

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Revenues and Costs per Horse-power per Annum.

In order to reduce the total revenues and total costs of operation to a basis where they would be comparable with other Systems and agree with the usual practice of similar companies and of distribution authorities, a set of diagrams has been prepared to show the revenue per horse-power per annum for different bases of horse-power, and to show the revenues per horse-power per annum from different main groups or classifications of consumers.

In a similar way, the total costs have been reduced to costs per horse-power per annum for different bases of horse-power, and have also been analyzed to show the total annual costs subdivided into fractional amounts chargeable against each kind of expense based on horse-power purchased, the average horse-power consumed and on the horse-power billed.

The following series of diagrams, with the table of figures for each, show these various items in detail.

The various municipalities located in the District have not generally being linked with power as such, and there is no desire to supply power. There is some desire for electric light and telephone service, and the various municipalities are interested in the same, and are working for the same. The various municipalities are interested in the same, and are working for the same. The various municipalities are interested in the same, and are working for the same.

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how these various items in detail.

See following pages of document, with the items as listed on page 1.

power consumed and on the power-billed.

against each kind of engine based on power-consumption, the various items to show the total amount of electricity used for each item.

power for each of the various items of power-consumption, and also the total power for each of the various items of power-consumption.

in a similar way, the total power for each item of power-consumption.

shown these different items groups in classification of documents.

different items of power-consumption, and in each item of power-consumption.

electricity for each item of power-consumption, and in each item of power-consumption.

usual practice of similar companies and of distribution companies, a way of

these items may be classified into three groups and power bills for

In order to obtain the power-consumption and total amount of electricity for

The various revenues for each classification of horse-power are given in the following table and on the sheet of curves included as page 62.

Table of Revenues per Horse-power per Annum

	Fiscal Years Ending October 31st.									
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Purchased	\$24.82	20.67	19.24	18.86	19.37	19.97	19.84	20.74	21.69	22.41
Consumed	-	-	-	-	-	-	-	23.78	29.78	31.46
Billed (Total)	23.90	20.21	19.60	19.04	18.60	18.83	17.41	19.70	21.14	21.30
Billed to Municipalities	23.62	19.17	19.06	19.65	19.45	19.33	17.46	20.27	21.00	22.40
Billed to Companies	28.36	29.23	22.61	17.23	16.35	16.18	17.20	17.39	21.96	17.30

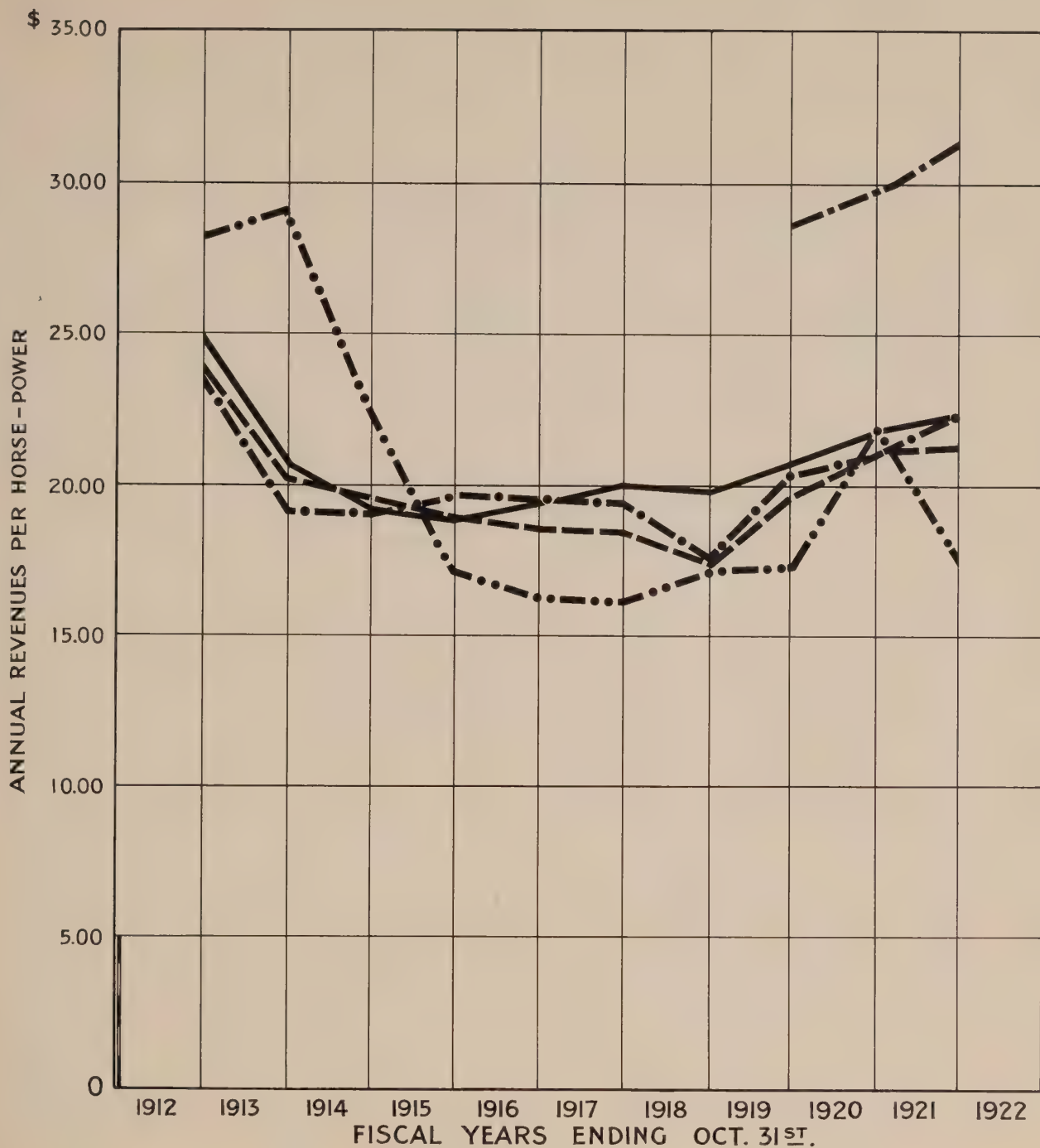
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Annual Costs per Horse-power.

The three sheets of curves included as pages 65, 66 and 67 and the tables on pages 63 and 64 show the details of the costs per horse-power per annum on different bases. The figures from which the curves were plotted are the figures for the operating costs given in the table on page 62 divided by the figures for the various classes of horse-power already given in the text. The sheet of curves included as page 68 indicates the total cost per horse-power per annum for the different classifications of horse-power already discussed. It will be noted that the total costs per horse-power per annum do not balance with the total revenues per horse-power per annum due to the profits or losses on sales of power to private companies which, as has been already explained, were later transferred to the reserve for contingencies.

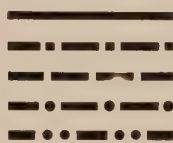
The sheet of curves included as page 65 entitled "Subdivided Costs per

VARIOUS HP BASES



REVENUE PER H.P. PURCHASED

" " " CONSUMED (AVERAGE)
 " " " BILLED (TOTAL)
 " " " " TO MUNICIPALITIES
 " " " " " COMPANIES



HYDRO-ELECTRIC INQUIRY COMMISSION
 W. D. GREGORY, CHAIRMAN

ECONOMICS OF H.E.P.C. DISTRIBUTION SYSTEMS

NIAGARA SYSTEM REVENUES PER H.P. PER ANNUM VARIOUS H.P. BASES

Toronto, June 15th, 1923. Made by S.R.M., Checked by C.H.

WALTER J. FRANCIS & COMPANY
 CONSULTING ENGINEERS

Horse-power for Power Purchased* indicates the subdivision of the total annual costs as between power purchased, operating, maintenance, overhead and general expense, interest, renewals, sinking fund and contingencies divided by the total amount of horse-power purchased by the Niagara System. Similarly the sheet of curves included as page 66 indicates the subdivided costs per average horse-power consumed and the sheet of curves included as page 67 indicates the subdivided costs per horse-power billed.

Table of Total Annual Costs per Horse-power

	Fiscal Years Ending October 31st,									
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Purchased	\$24.84	20.67	19.22	19.84	19.38	19.98	19.66	20.38	21.61	22.44
Consumed	-	-	-	-	-	-	-	28.95	29.68	31.48
Billed (Total)	23.93	20.18	19.60	19.03	18.63	18.53	17.26	19.85	21.03	21.32

Table of Subdivided Annual Costs per Horse-power Purchased

	Fiscal Years Ending October 31st,									
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Power Purchased	\$9.37	9.00	9.00	9.00	9.48	9.92	10.07	10.25	11.36	12.55
Operation	2.37	1.16	1.02	.75	.88	.80	.84	1.11	1.19	1.01
Maintenance	1.89	1.15	1.85	1.40	1.72	1.34	1.23	1.23	.83	.86
Overhead	1.02	.71	.63	.60	.43	.45	.80	1.08	1.44	1.55
Interest	7.51	4.96	3.96	4.09	3.53	3.28	3.50	3.95	3.73	3.43
Renewals	)						1.94	1.99	1.80	1.68
Sinking Fund	)	2.68	3.69	2.76	3.00	3.34	3.69	1.00	1.02	1.11
Contingencies	)						.27	.25	.22	.20
	\$24.84	20.67	19.22	19.84	19.38	19.98	19.66	20.38	21.61	22.44

Divided costs per horse-power billed.

These figures are based on the assumption that the total cost of the plant is \$1,000,000 and that the total capacity is 10,000 horse-power. The figures are based on the assumption that the plant is operated at full capacity and that the total cost is divided equally among the units.

Table of Total Annual Costs per Horse-power

1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	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30.00

Subdivided Annual Costs per Horse-power Consumed

	Fiscal Years Ending October 31st.		
	1919	1920	1921
Power Purchased	\$14.20	\$15.60	\$17.60
Operation	1.54	1.51	1.42
Maintenance	1.72	1.14	1.21
Overhead	1.50	1.98	2.17
Interest	5.47	5.13	4.88
Renewals	2.76	2.47	2.36
Sinking Fund	1.41	1.55	1.56
Contingencies	.35	.30	.28
Totals	\$28.95	\$29.68	\$31.48

Table of Subdivided Annual Costs per Horse-power Billed

	Fiscal Years Ending October 31st.									
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Power Purchased	9.03	8.79	9.18	9.09	9.12	9.23	8.84	9.74	11.06	11.92
Operation	2.28	1.13	1.04	.76	.85	.74	.74	1.06	1.07	.96
Maintenance	1.82	1.12	1.89	1.41	1.65	1.71	1.08	1.17	.91	.82
Overhead	.98	.69	.64	.61	.41	.42	.70	1.03	1.40	1.47
Interest	7.24	4.85	4.04	4.13	3.39	3.04	3.07	3.75	3.63	3.31
Renewals							1.70	1.09	1.75	1.60
Sinking Fund	2.58	3.60	2.81	3.93	3.21	3.42	.88	.97	1.14	1.06
Contingencies							.24	.24	.21	.19
Totals	\$23.93	20.18	19.60	19.03	18.63	18.53	17.25	19.85	21.03	21.32

FISCAL YEARS ENDING OCT. 31ST.

HYDRO-ELECTRIC INQUIRY COMMISSION
IN ENQUIRY OF

MEMBERS OF H.E.P.C. DISTRICT

NIAGARA SYSTEM
SUBDIVIDED ANNUAL COSTS
PER H.P. PURCHASED

Toronto, January 15th, 1922

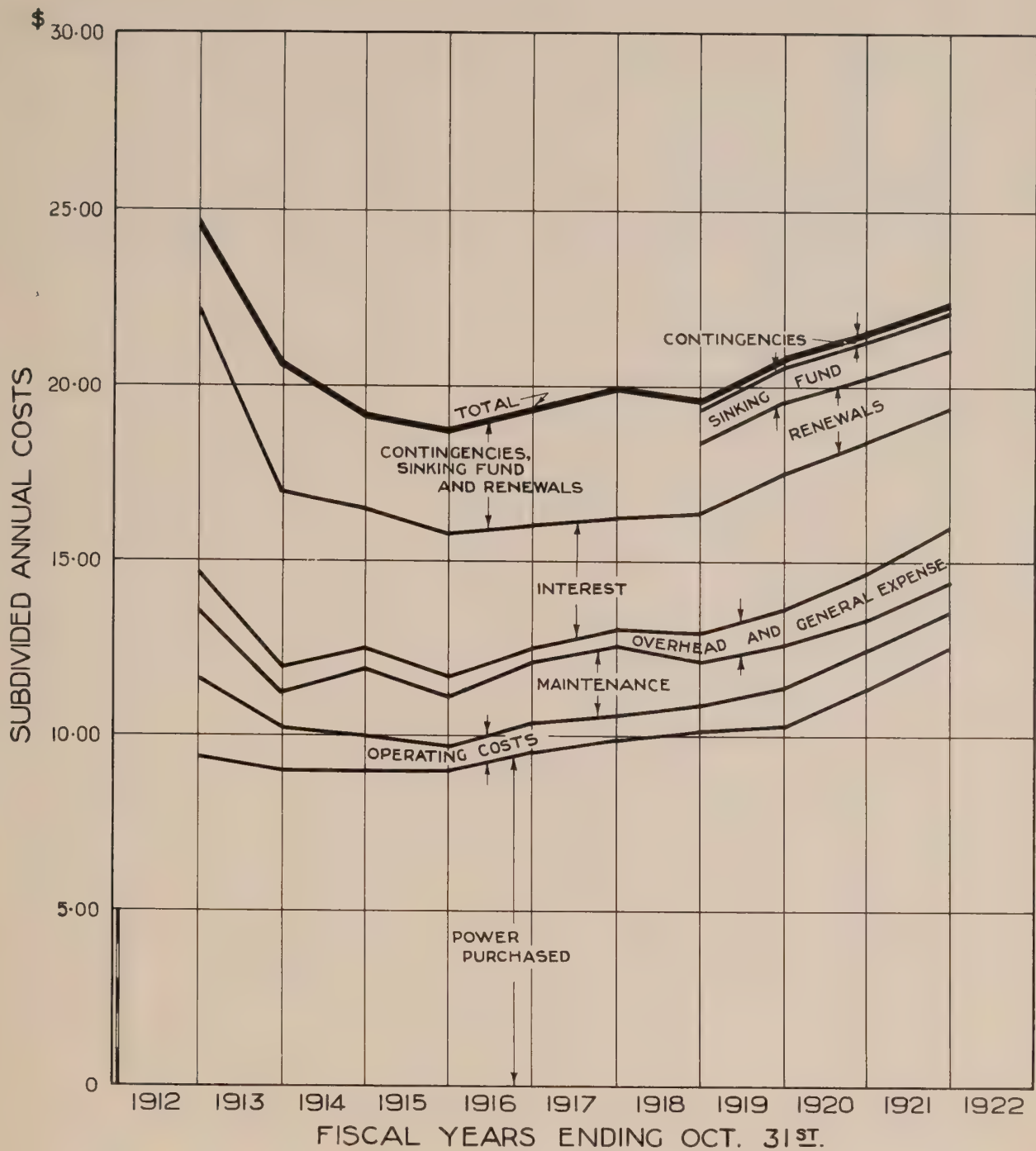
WALTER J. FRANCIS & COMPANY

Statement of Assets and Liabilities

Assets			Liabilities		
1911	1912	1913	1911	1912	1913
Real Estate	10,000	10,000	Notes Payable	5,000	5,000
Stocks	5,000	5,000	Accounts Payable	2,000	2,000
Bonds	5,000	5,000	Other Liabilities	1,000	1,000
Accounts Receivable	1,000	1,000			
Prepaid Insurance	500	500			
Other Assets	500	500			
Total	22,000	22,000	Total	8,000	8,000

Statement of Income and Expenses

Income			Expenses		
1911	1912	1913	1911	1912	1913
Interest	1,000	1,000	Interest	500	500
Dividends	500	500	Salaries	1,000	1,000
Rent	1,000	1,000	Other Expenses	500	500
Other Income	500	500			
Total	3,000	3,000	Total	2,000	2,000



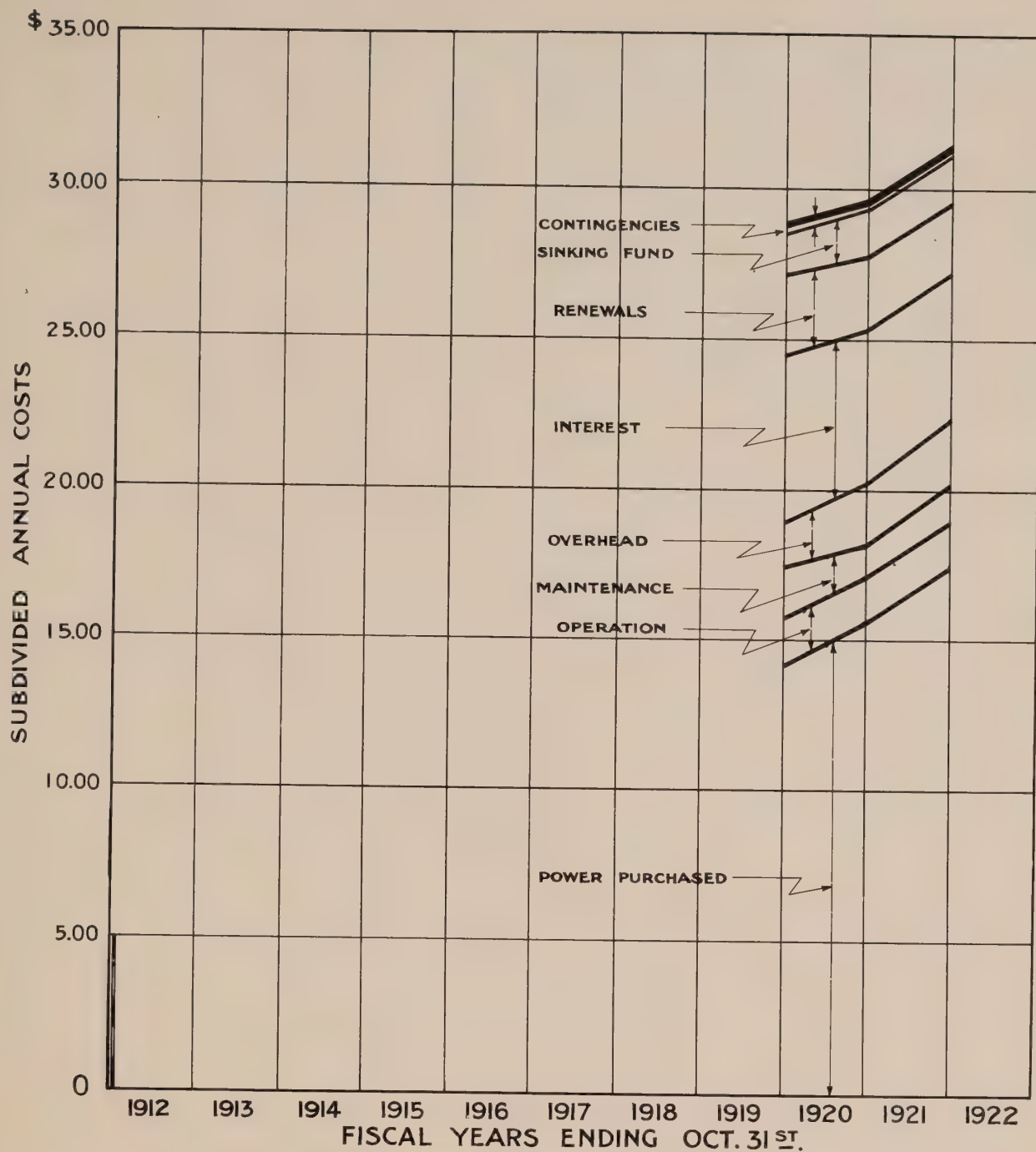
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

**NIAGARA SYSTEM
SUBDIVIDED ANNUAL COSTS
PER H.P. PURCHASED**

Toronto, June 15th, 1923. Made by *WJF*, Checked by *WJF*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



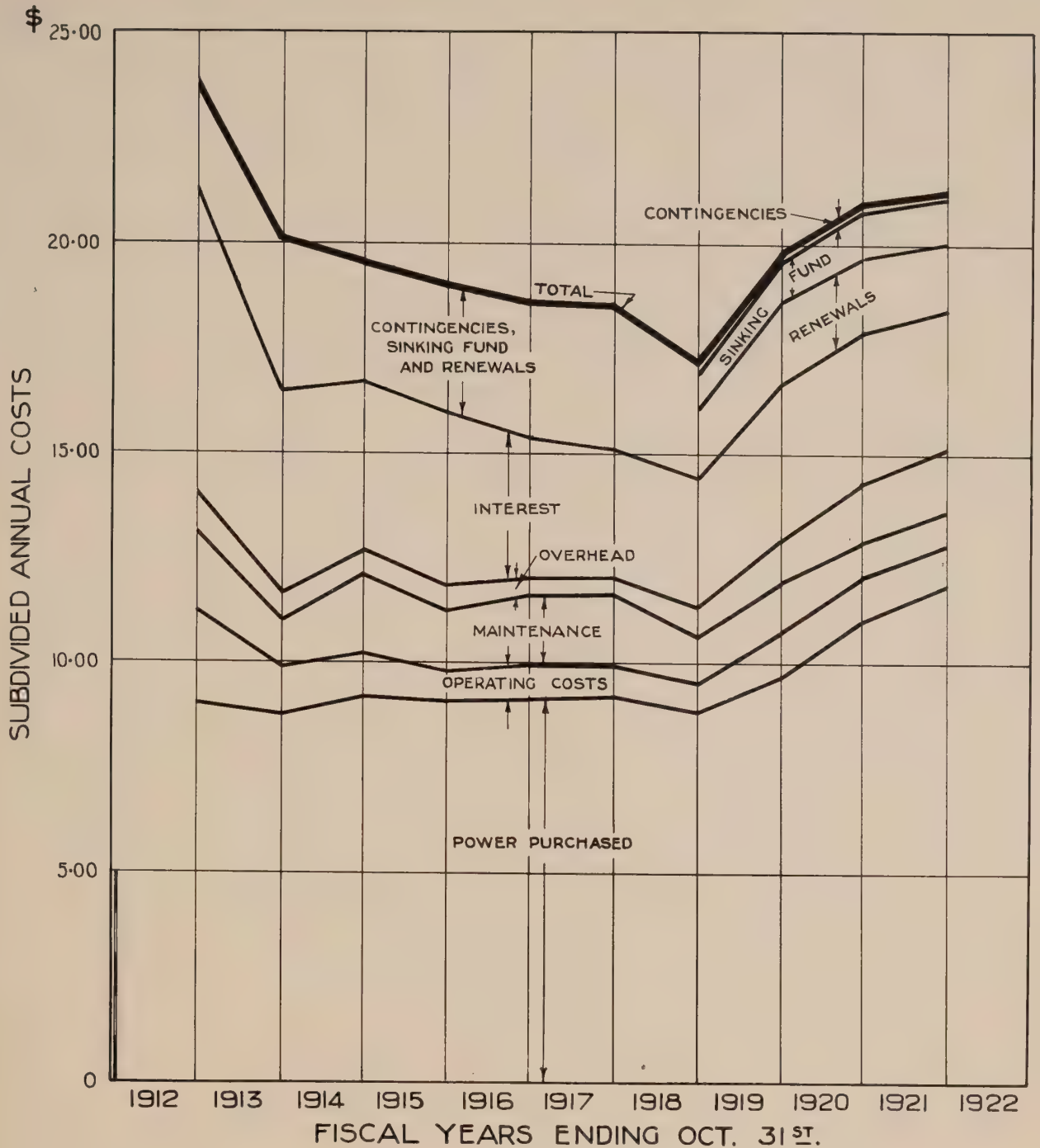
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

**NIAGARA SYSTEM
SUBDIVIDED ANNUAL COSTS
PER H.P. CONSUMED**

Toronto, June 15th, 1923. Made by *SRW*, Checked by *WJF*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



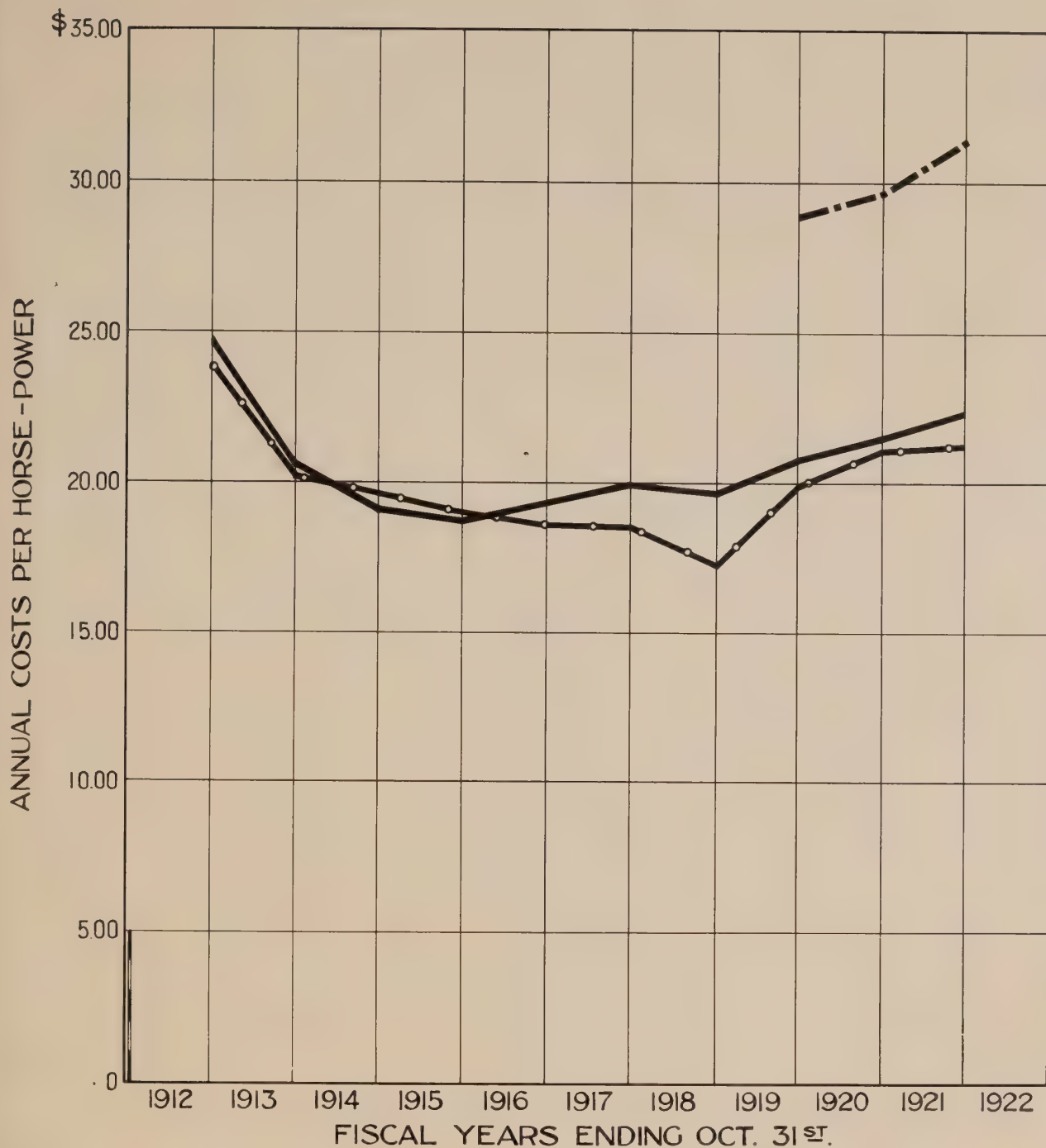
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

**NIAGARA SYSTEM
SUBDIVIDED ANNUAL COSTS
PER H.P. BILLED**

Toronto, June 15th, 1923. Made by *WJF*, Checked by *L.H.*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



COST PER H. P. PURCHASED
 " " " AVERAGE CONSUMED
 " " " BILLED TOTAL



HYDRO-ELECTRIC INQUIRY COMMISSION
 W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

**NIAGARA SYSTEM
 COSTS PER H. P. PER ANNUM
 VARIOUS H. P. BASES**

Toronto, June 15th, 1923. Made by *g&g*, Checked by *L.H.*

WALTER J. FRANCIS & COMPANY
 CONSULTING ENGINEERS

Kilowatt-hour Data and Annual Revenues and Costs per Kilowatt-hour.

The table below shows the kilowatt-hours supplied to the Niagara System for the fiscal years 1919 to 1922 inclusive. These figures were supplied by the engineers of the Hydro-Electric Power Commission, and they represent the energy delivered as measured at Niagara Falls, and, therefore, include energy consumed by the line losses:

Kilowatt-hours Supplied to the Niagara System

Fiscal Year Ending October 31st,		Kilowatt-hours Supplied
1919	COPY figures, as certain small errors	827,151,520
1920		823,324,019
1921		891,607,900
1922		951,362,934

The table below and the sheet of curves on page 71 show the total revenues and total costs and the subdivided costs per kilowatt-hour for the three years ending October 31st, 1919, 1920 and 1921. The cost per kilowatt-hour for power purchased in 1922 is also shown, but the operating costs for this year are not available.

The following table and the curves on page 72 show the average cost per kilowatt-hour for power purchased in 1922.

Figures were furnished by the engineers of the Hydro-Electric Power Commission.

0-50

Table of Subdivided Costs in Cents per Kilowatt-hour Supplied

	Fiscal Year Ending October 31st,			
	1919	1920	1921	1922
Power Purchased	.2176	.2368	.2705	.3874
Operating Costs	.0236	.0231	.0216	
Maintenance	.0261	.0175	.0186	
Overhead and General Expense	.0228	.0305	.0333	
Interest	.0837	.0783	.0750	
Renewals	.0422	.0377	.0362	
Sinking Fund	.0217	.0238	.0238	
Contingencies	.0054	.0046	.0042	
Total Costs	.4431	.4543	.4632	
Total Revenues	.4404	.4556	.4814	

The total revenues and total costs per kilowatt-hour do not balance exactly in the various years, as certain small surpluses or deficits resulted in these years from the sale of power to private companies.

These total costs are the costs at the distributing stations based on energy supplied at Niagara Falls. If allowance is made for the line losses, and if the costs of retail distribution are added, these costs will be very largely increased. It must also be borne in mind that the energy supplied to private customers such as companies and manufacturing plants, is included.

1919 1920 1921 1922
Costs of Power Purchased for the Niagara System.

The following table and the curve on page 73 show the average cost per horse-power per annum for "purchased power" for the Niagara System. The figures were furnished by the accountants of the Hydro-Electric Power Commission.

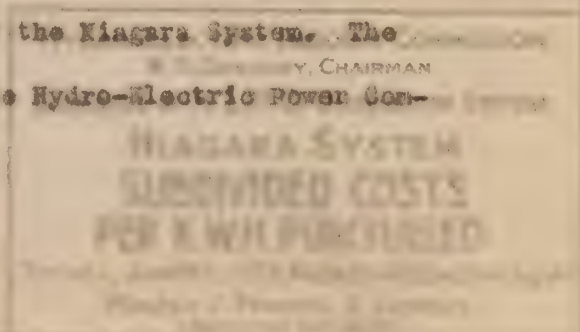


TABLE 1. SUMMARY OF THE

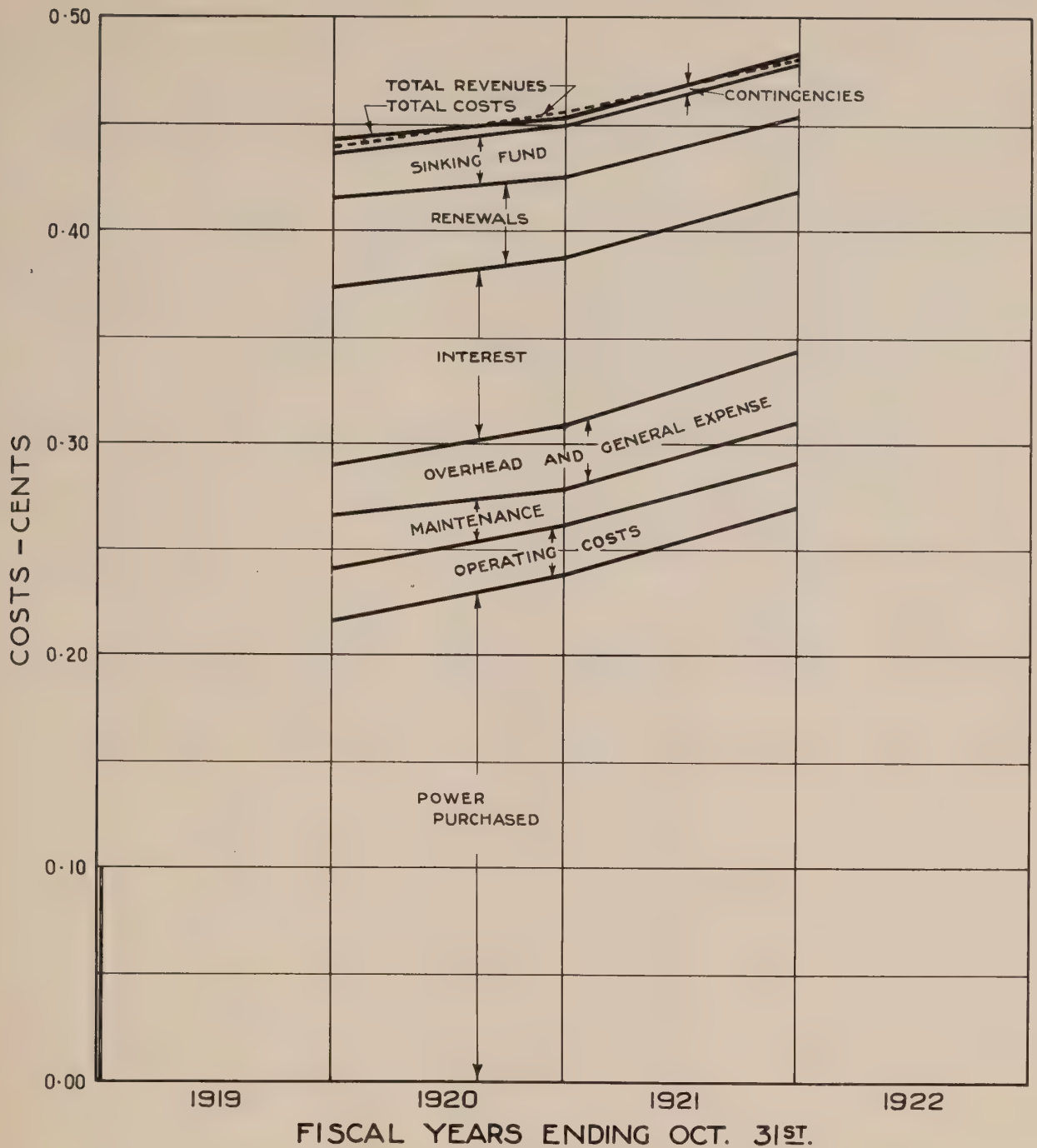
Item	Amount in Dollars		
	1911	1912	1913
Power purchased	1,217	1,217	1,217
Operating costs	1,217	1,217	1,217
Maintenance	1,217	1,217	1,217
Overhead and interest charges	1,217	1,217	1,217
Insurance	1,217	1,217	1,217
Taxes	1,217	1,217	1,217
Depreciation	1,217	1,217	1,217
Operating profit	1,217	1,217	1,217
Interest on bonds	1,217	1,217	1,217
Dividend	1,217	1,217	1,217
Reserve	1,217	1,217	1,217
Profit	1,217	1,217	1,217

COPY

The total revenue
 in these years from the sale of power to private companies.
 These total costs are the same as the distribution
 by
 the

TABLE 2. SUMMARY OF THE

The following table



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

**NIAGARA SYSTEM
SUBDIVIDED COSTS
PER K.W.H. PURCHASED**

Toronto, June 15th, 1923. Made by *W.J.F.* Checked by *L.H.*

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

\$ 20.00

Costs of Power Purchased for Niagara System - Years 1911 to 1922, Inclusive

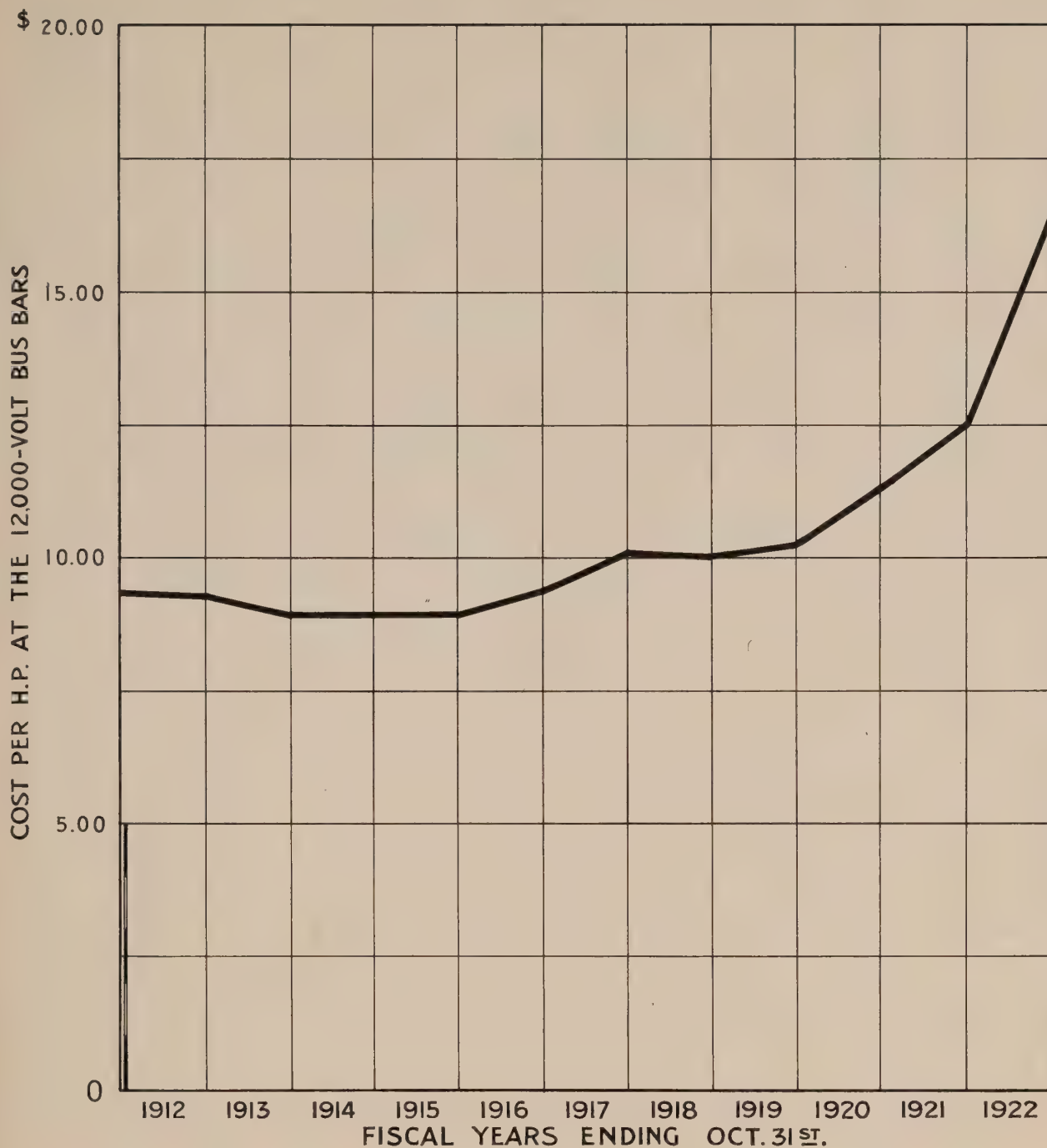
<u>1911</u>	Power bought from Ontario Power Company	7,948.33 H.P. at	9.40 -	\$ 74,714.22
<u>1912</u>	Power bought from Ontario Power Company	18,212.5 H.P. at	9.40 -	171,197.25
		2,407.4 H.P. at	9.00 -	21,666.75
		20,619.9		192,864.00
<u>1913</u>	Power bought from Ontario Power Company	36,334.16 H.P. at	9.00 -	327,007.47
<u>1914</u>	Power bought from Ontario Power Company	51,677.6 H.P. at	9.00 -	465,098.31
<u>1915</u>	Power bought from Ontario Power Company	79,877.3 H.P. at	9.00 -	718,895.50
<u>1916</u>	Power bought from Ontario Power Company	91,237.85 H.P. at	9.00 -	821,140.64
	Power bought from Canadian Niagara Power Company	5,778.17 H.P. at	12.00 -	69,338.03
	Power bought from Toronto Power Company	8,213.76 H.P. at	13.00 -	106,778.93
	Total purchased	-	105,229.78 H.P.	\$997,257.60

Average cost of power \$ 9.48 per H.P. per annum.

<u>1917</u>	Power bought from Ontario Power Company	91,341.48 H.P. at	9.00 -	\$822,073.33
	Amount paid to The Ontario Power Company as settlement of all outstanding claims and differences regarding meter readings, meter errors, etc. in connection with the supply of power from March 1914 to May 1917			25,000.00
	Power bought from Canadian Power Company	40,712.55 H.P. at	12.00 -	488,550.62
	Toronto Power Company Underpayment July 1916			90.00
		132,054.03 H.P.		\$1,335,713.95

Average cost of power \$10.11 per H.P. per annum.

NIAGARA SYSTEM
COST PER HORSE-POWER
DELIVERED TO THE NIAGARA SYSTEM



HYDRO-ELECTRIC INQUIRY COMMISSION
 W. D. GREGORY, CHAIRMAN
 ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
NIAGARA SYSTEM
COST PER HORSE-POWER
DELIVERED TO THE NIAGARA SYSTEM
 Toronto, June 15th, 1923. Made by S.R.W., Checked by *W.F.*
WALTER J. FRANCIS & COMPANY
 CONSULTING ENGINEERS

Costs of Power Purchased for Niagara System - Years 1911 to 1922, Inclusive
(Continued)

1918

Power bought from Ontario Power Company 92,647.8 H.P. at 9.00 - \$833,830.24

Power bought from Canadian Niagara
Power Company

44,994.6 H.P. at 12.00 - 539,937.81

Payment in full of award of the cost of
arbitration Toronto Power Company and
Hydro-Electric Power Commission cover-
ing all outstanding claims for damages
to machinery, meter errors, etc.

6,942.45

Cancelling Ontario National Brick Com-
pany's 1917 account and reversing all
charges. (Company went into liquidation)

4,995.91

137,642.6 H.P. \$1,385,706.41

Average cost of power \$10.07 per H.P. per annum.

1919

Power bought from Ontario Power Company 94,652.7 H.P. at 9.00 - \$851,874.28
3,494.9 H.P. at 12.00 - 41,939.30

Power bought from Canadian Niagara
Power Company

49,883 H.P. at 12.00 - 598,596.99

Amount paid to the Canadian Niagara
Power Company as full settlement of
all outstanding claims for damage to
machinery, meter reading differences,
etc. amount was charged into the cost of

25,000.00

Legal fees

47.00

148,030.6 H.P. \$1,517,457.57

Average cost of power \$10.25 per H.P. per annum.

Costs of power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Payment in full of award of the cost of
the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Average cost of power consumed in the operation of the plant during the year 1911 as shown by the following statement:

Costs of Power Purchased for Niagara System - Years 1911 to 1922, Inclusive
(Continued)

1920

Power bought from Ontario Power Company	96,720.2 H.P. at 9.00 -	\$870,482.16
	20,194.7 H.P. at 12.00 -	242,356.24

Power bought from Canadian Niagara Power Company	48,723.6 H.P. at 12.00 -	584,683.07
	7,274.3 H.P. at 18.00 -	130,937.25

Amount paid to the Electro-Metals, Limited to release The Ontario Power Company from contract to supply 11,000 H.P. in order that this power would be available for the use of the Hydro-Electric Power Commission		59,812.47
--	--	-----------

Amount paid to the Canadian Niagara Power Company for reactance coils (\$25,000.00 to be written off over a period of 10 years). This amount represents an accumulation of installments for three years		6,310.05
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Toronto Hydro-Electric System (for Scarborough Township and Markham)		1,589.01
--	--	----------

Legal expenses in connection with arbitration proceedings, Canadian Niagara Power Company and Hydro-Electric Power Commission		950.00
---	--	--------

Union Carbide Company's shortage for 1920. This amount was charged into the cost of power to the Niagara System because of the arrangement with this Company whereby the Commission supplied only off-peak power in order that more power would be available for the use of the Niagara municipalities		69,204.09
--	--	-----------

172,912.8 H.P.	\$1,966,304.34
----------------	----------------

Average cost of power \$11.36 per H.P. per annum.

State of New York, County of Albany, ss. I, the undersigned, Clerk of the County, do hereby certify that the within and foregoing is a true and correct copy of the original as the same appears on file in my office.

1771

Power Company, New York, New York, ss. I, the undersigned, Clerk of the County, do hereby certify that the within and foregoing is a true and correct copy of the original as the same appears on file in my office.

Power Company, New York, New York, ss. I, the undersigned, Clerk of the County, do hereby certify that the within and foregoing is a true and correct copy of the original as the same appears on file in my office.

1771

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Power Company, New York, New York, ss. I, the undersigned, Clerk of the County, do hereby certify that the within and foregoing is a true and correct copy of the original as the same appears on file in my office.

1771

1771

Power Company, New York, New York, ss. I, the undersigned, Clerk of the County, do hereby certify that the within and foregoing is a true and correct copy of the original as the same appears on file in my office.

Costs of Power Purchased for Niagara System - Years 1911 to 1922, Inclusive
(Continued)

1921

Power bought from Ontario Power Company	97,032.75 H.P. at 9.00 -	\$873,294.75
	33,770.83 H.P. at 18.00 -	607,875.00
	11,000 H.P. at 12.75 -	140,250.00

Power bought from Canadian Niagara Power Company	49,769.28 H.P. at 12.00 -	597,231.40
--	---------------------------	------------

Amount paid to the Electro-Metals, Limited to release The Ontario Power Company from contract to supply 11,000 H.P. in order that this power would be available for the use of the Hydro-Electric Power Commission		79,749.96
--	--	-----------

Toronto Hydro-Electric System (for Scarborough Township and Northam)		6,206.87
--	--	----------

Amount paid to Canadian Niagara Power Company for reactance coil, (fourth installment)		2,100.00
--	--	----------

Union Carbide Company's shortage for 1921.
This amount was charged in the cost of power to the Niagara System because of the arrangement with this Company whereby the Commission supplied only off-peak power in order that more power would be available for the use of the Niagara municipalities

105,227.32

191,572.86 H.P.	\$2,411,966.30
-----------------	----------------

Average cost of power \$12.55 per H.P. per annum.

$\sigma_{\text{max}} = 100.6 \text{ MPa}$ at $x = 0$, $y = 0$, $z = 0$
 $\sigma_{\text{min}} = -100.6 \text{ MPa}$ at $x = 0$, $y = 0$, $z = 0$
 $\sigma_{\text{max}} = 100.6 \text{ MPa}$ at $x = 0$, $y = 0$, $z = 0$

1945-1946 - 1947-1948 - 1949-1950 - 1951-1952 - 1953-1954 - 1955-1956 - 1957-1958 - 1959-1960 - 1961-1962 - 1963-1964 - 1965-1966 - 1967-1968 - 1969-1970 - 1971-1972 - 1973-1974 - 1975-1976 - 1977-1978 - 1979-1980 - 1981-1982 - 1983-1984 - 1985-1986 - 1987-1988 - 1989-1990 - 1991-1992 - 1993-1994 - 1995-1996 - 1997-1998 - 1999-2000 - 2001-2002 - 2003-2004 - 2005-2006 - 2007-2008 - 2009-2010 - 2011-2012 - 2013-2014 - 2015-2016 - 2017-2018 - 2019-2020 - 2021-2022 - 2023-2024 - 2025-2026 - 2027-2028 - 2029-2030 - 2031-2032 - 2033-2034 - 2035-2036 - 2037-2038 - 2039-2040 - 2041-2042 - 2043-2044 - 2045-2046 - 2047-2048 - 2049-2050 - 2051-2052 - 2053-2054 - 2055-2056 - 2057-2058 - 2059-2060 - 2061-2062 - 2063-2064 - 2065-2066 - 2067-2068 - 2069-2070 - 2071-2072 - 2073-2074 - 2075-2076 - 2077-2078 - 2079-2080 - 2081-2082 - 2083-2084 - 2085-2086 - 2087-2088 - 2089-2090 - 2091-2092 - 2093-2094 - 2095-2096 - 2097-2098 - 2099-2100 - 2101-2102 - 2103-2104 - 2105-2106 - 2107-2108 - 2109-2110 - 2111-2112 - 2113-2114 - 2115-2116 - 2117-2118 - 2119-2120 - 2121-2122 - 2123-2124 - 2125-2126 - 2127-2128 - 2129-2130 - 2131-2132 - 2133-2134 - 2135-2136 - 2137-2138 - 2139-2140 - 2141-2142 - 2143-2144 - 2145-2146 - 2147-2148 - 2149-2150 - 2151-2152 - 2153-2154 - 2155-2156 - 2157-2158 - 2159-2160 - 2161-2162 - 2163-2164 - 2165-2166 - 2167-2168 - 2169-2170 - 2171-2172 - 2173-2174 - 2175-2176 - 2177-2178 - 2179-2180 - 2181-2182 - 2183-2184 - 2185-2186 - 2187-2188 - 2189-2190 - 2191-2192 - 2193-2194 - 2195-2196 - 2197-2198 - 2199-2200 - 2201-2202 - 2203-2204 - 2205-2206 - 2207-2208 - 2209-2210 - 2211-2212 - 2213-2214 - 2215-2216 - 2217-2218 - 2219-2220 - 2221-2222 - 2223-2224 - 2225-2226 - 2227-2228 - 2229-2230 - 2231-2232 - 2233-2234 - 2235-2236 - 2237-2238 - 2239-2240 - 2241-2242 - 2243-2244 - 2245-2246 - 2247-2248 - 2249-2250 - 2251-2252 - 2253-2254 - 2255-2256 - 2257-2258 - 2259-2260 - 2261-2262 - 2263-2264 - 2265-2266 - 2267-2268 - 2269-2270 - 2271-2272 - 2273-2274 - 2275-2276 - 2277-2278 - 2279-2280 - 2281-2282 - 2283-2284 - 2285-2286 - 2287-2288 - 2289-2290 - 2291-2292 - 2293-2294 - 2295-2296 - 2297-2298 - 2299-2300 - 2301-2302 - 2303-2304 - 2305-2306 - 2307-2308 - 2309-2310 - 2311-2312 - 2313-2314 - 2315-2316 - 2317-2318 - 2319-2320 - 2321-2322 - 2323-2324 - 2325-2326 - 2327-2328 - 2329-2330 - 2331-2332 - 2333-2334 - 2335-2336 - 2337-2338 - 2339-2340 - 2341-2342 - 2343-2344 - 2345-2346 - 2347-2348 - 2349-2350 - 2351-2352 - 2353-2354 - 2355-2356 - 2357-2358 - 2359-2360 - 2361-2362 - 2363-2364 - 2365-2366 - 2367-2368 - 2369-2370 - 2371-2372 - 2373-2374 - 2375-2376 - 2377-2378 - 2379-2380 - 2381-2382 - 2383-2384 - 2385-2386 - 2387-2388 - 2389-2390 - 2391-2392 - 2393-2394 - 2395-2396 - 2397-2398 - 2399-2400 - 2401-2402 - 2403-2404 - 2405-2406 - 2407-2408 - 2409-2410 - 2411-2412 - 2413-2414 - 2415-2416 - 2417-2418 - 2419-2420 - 2421-2422 - 2423-2424 - 2425-2426 - 2427-2428 - 2429-2430 - 2431-2432 - 2433-2434 - 2435-2436 - 2437-2438 - 2439-2440 - 2441-2442 - 2443-2444 - 2445-2446 - 2447-2448 - 2449-2450 - 2451-2452 - 2453-2454 - 2455-2456 - 2457-2458 - 2459-2460 - 2461-2462 - 2463-2464 - 2465-2466 - 2467-2468 - 2469-2470 - 2471-2472 - 2473-2474 - 2475-2476 - 2477-2478 - 2479-2480 - 2481-2482 - 2483-2484 - 2485-2486 - 2487-2488 - 2489-2490 - 2491-2492 - 2493-2494 - 2495-2496 - 2497-2498 - 2499-2500 - 2501-2502 - 2503-2504 - 2505-2506 - 2507-2508 - 2509-2510 - 2511-2512 - 2513-2514 - 2515-2516 - 2517-2518 - 2519-2520 - 2521-2522 - 2523-2524 - 2525-2526 - 2527-2528 - 2529-2530 - 2531-2532 - 2533-2534 - 2535-2536 - 2537-2538 - 2539-2540 - 2541-2542 - 2543-2544 - 2545-2546 - 2547-2548 - 2549-2550 - 2551-2552 - 2553-2554 - 2555-2556 - 2557-2558 - 2559-2560 - 2561-2562 - 2563-2564 - 2565-2566 - 2567-2568 - 2569-2570 - 2571-2572 - 2573-2574 - 2575-2576 - 2577-2578 - 2579-2580 - 2581-2582 - 2583-2584 - 2585-2586 - 2587-2588 - 2589-2590 - 2591-2592 - 2593-2594 - 2595-2596 - 2597-2598 - 2599-2600 - 2601-2602 - 2603-2604 - 2605-2606 - 2607-2608 - 2609-2610 - 2611-2612 - 2613-2614 - 2615-2616 - 2617-2618 - 2619-2620 - 2621-2622 - 2623-2624 - 2625-2626 - 2627-2628 - 2629-2630 - 2631-2632 - 2633-2634 - 2635-2636 - 2637-2638 - 2639-2640 - 2641-2642 - 2643-2644 - 2645-2646 - 2647-2648 - 2649-2650 - 2651-2652 - 2653-2654 - 2655-2656 - 2657-2658 - 2659-2660 - 2661-2662 - 2663-2664 - 2665-2666 - 2667-2668 - 2669-2670 - 2671-2672 - 2673-2674 - 2675-2676 - 2677-2678 - 2679-2680 - 2681-2682 - 2683-2684 - 2685-2686 - 2687-2688 - 26

1. The first of these is the fact that the
2. United States is not a member of the
3. Organization for Economic Cooperation and
4. Development (OECD). This is a serious
5. handicap to the United States in the
6. competition for foreign investment and
7. trade. The OECD is a group of 21
8. industrialized countries which have
9. agreed to work together to promote
10. economic growth and development. The
11. United States is not a member of this
12. group, and this is a serious handicap
13. to the United States in the competition
14. for foreign investment and trade.

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Costs of Power Purchased for Niagara System - Years 1911 to 1922, Inclusive
(Continued)

1922

Power bought from Ontario Power Company	78,438.08 H.P. at 9.00 -	\$705,942.78
	23,283.36 H.P. at 18.00 -	419,100.54
Additional cost		<u>524,567.22</u>
		\$1,649,610.54
Power bought from Canadian Niagara Power Company	49,611.15 H.P. at 12.00 -	595,333.82
Power delivered from Queenston Generating Station	73,996 H.P. at 20.00 -	1,479,934.51
Power bought from Toronto Hydro-Electric System (for Scarborough and Markham)	372.7 H.P.	9,243.30
Power bought from Municipality of Thorold (for Jordan Rural District)		41.47
Amount paid Canadian Niagara Power Company for reactance coil		<u>2,100.00</u>
	225,701.29 H.P.	<u>\$3,736,263.64</u>
<hr/>		
Average cost of power	<u>\$16.55 per H.P. per annum.</u>	

It will be noted from the table that the cost of power decreased from 1911 to 1913, and then remained constant until 1915. In 1916 the average cost was almost the same as in 1911. In 1917, 1918 and 1919 the cost was slightly higher than in 1916, but was practically constant in those three years. From 1920 to the present time the cost of power has increased rapidly.

The reasons for the increase of the average cost of power purchased are that in the early years all of the power was purchased from The Ontario Power Company under the original agreement, and that additional power subsequently

required could not be bought at the same rates. Under this original agreement the price per horse-power per annum was reduced from \$9.40 per horse-power per annum to \$9.00 per horse-power per annum when the demand reached 25,000 horse-power. In 1916 the power required for the Niagara System reached the total of 100,000 horse-power permissible under the original agreement with The Ontario Power Company. It then became necessary to purchase additional power from other sources and the prices were increased. In 1916 a small block of power was purchased from the Toronto Power Company at \$13.00 per horse-power per annum and in the same year arrangements were made with the Canadian Niagara Power Company to purchase a total of 50,000 horse-power at \$12.00 per horse-power per annum, and a small portion of this block was purchased in 1916. In 1917 all of the purchased power was supplied by The Ontario Power Company and by the Canadian Niagara Power Company. In 1918 and 1919 the same arrangements applied but in the latter year a small part of the power from The Ontario Power Company was billed at \$12.00 in addition to the original agreement at \$9.00. In 1920 the full amount under the Canadian Niagara Power Company's contract was reached in some months and the excess was billed at \$18.00 per horse-power per annum.

Commencing November 1st, 1920, it is stated by the engineers of the Hydro-Electric Power Commission that it was decided to pool all power purchased by the Hydro-Electric Power Commission at Niagara Falls through The Ontario Power Company. With the exception of one block of 10,723 horse-power which was received from the Niagara Falls Power Company from the American side during the period from November 13th, 1920, to January 31st, 1922, and from April 20th, 1922, to May 31st, 1922, this has been done. The pooling of the purchased power through

The Ontario Power Company is stated to have been decided upon after a great deal of thought and study had been given to the question of operation of the interconnected generating stations at Niagara Falls and the rather complicated situation which arose owing to the physical connections for the delivery of power and the relation of the contracts which covered the same. The experience of the Commission is stated to be that the accounting has been greatly simplified and that it feels that the pooling arrangement represents the most equitable method obtainable for handling the situation in view of the circumstances which existed.

In 1921, also, a considerable portion of the power from The Ontario Power Company was billed at \$18.00 and another block at \$12.75, while the full amount from the Canadian Niagara Power Company was billed at \$12.00.

In 1922, it is stated by the accountants of the Hydro-Electric Power Commission, that it was decided to operate The Ontario Power Company plant at cost to the Niagara System. As the Company is a separate legal entity with a number of fixed rate contracts it was necessary to honour these agreements and bill all these customers at their contract rates. As some of these contracts are apparently being carried on at a loss, the Niagara System would necessarily bear this loss on the other contracts if it were billed with "power at cost" from The Ontario Power Company. As the Hydro-Electric Power Commission has a contract for 100,000 horse-power at \$9.00 per horse-power per annum, on a monthly billing basis, and also had a somewhat indefinite arrangement for another smaller block of power at \$13.00 per horse-power per annum, the amounts taken under these arrangements were billed at the contract rates and adjusted

later by the addition of the amount of \$524,567.22 as "additional cost".

The total figures for purchased power in 1922 are given as follows:

Tables of Power Purchased for the Niagara System - Fiscal Year 1922

Canadian Niagara Power Company

Year	Month	Horse-power	Amount
<u>1921</u>	November	50,000	\$50,000.00
	December	50,000	50,000.00
<u>1922</u>	January	47,024.35	47,024.35
	February	49,946.76	49,946.76
	March	49,887.91	49,887.91
	April	49,974.80	49,974.80
	May	50,000	50,000.00
	June	50,000	50,000.00
	July	50,000	50,000.00
	August	50,000	50,000.00
	September	50,000	50,000.00
	October	48,500	48,500.00
Total		595,333.82 H. P. months for	\$595,333.82

Queenston Generating Station

<u>1921</u>	November	-	-
	December	-	-
<u>1922</u>	January	1,765.5	\$ 2,975.65
	February	53,519	89,365.00
	March	73,039.98	121,683.30
	April	81,823.8	136,373.43
	May	86,300	93,835.35
	June	112,600	187,666.66
	July	115,281	192,135.00
	August	115,281	192,135.00
	September	115,281	192,135.00
	October	162,972.9	271,632.14
Total		887,950.98 H. P. months for	\$1,479,934.51

Tables of Power Purchased for the Niagara System - Fiscal Year 1922
(Continued)

The Ontario Power Company of Niagara Falls

Year	Month	Horse-power at \$9.00	Amount	Horse-power at \$15.00	Amount
<u>1921</u>					
	November	96,381	\$72,285.75	81,422	\$122,133.00
	December	96,113	72,084.75	80,156	120,249.00
<u>1922</u>					
	January	96,159	72,119.25	79,303	118,954.50
	February	96,169	72,126.75	20,460	30,690.00
	March	82,757.3	62,075.48	8,686.36	13,029.54
	April	83,987.5	62,990.63	6,032	9,048.00
	May	96,381	72,285.75	3,331	4,996.50
	June	48,001	36,000.75	-	-
	July	55,989	41,991.75	-	-
	August	59,534	44,650.50	-	-
	September	80,540	60,405.00	-	-
	October	49,235.22	36,926.42	-	-
		941,257.02	\$705,942.78	279,400.36	\$419,100.54

"Additional Cost" - \$ 524,567.22

Total from The Ontario Power Company - \$1,649,610.54

Recapitulation

	<u>Yearly Average Horse-power</u>	<u>Amount</u>
Canadian Niagara Power Company	49,611.15	\$ 595,333.82
The Ontario Power Company	101,721.44	1,649,610.54
Queenston Generating Station	73,996.74	<u>1,479,934.51</u>
		3,724,878.87
Miscellaneous items		<u>11,384.77</u>
Total paid for power in 1922		\$3,736,263.64

Notice is hereby given that the following is a list of the names of the persons who have been elected to the office of the Board of Directors of the City of Philadelphia for the year 1901.

The following is a list of the names of the persons who have been elected to the office of the Board of Directors of the City of Philadelphia for the year 1901.

Year	Street	House No.	City	State	Occupation
1901	1st St	100	St. Louis	Mo.	Merchant
1901	2nd St	200	St. Louis	Mo.	Lawyer
1901	3rd St	300	St. Louis	Mo.	Physician
1901	4th St	400	St. Louis	Mo.	Engineer
1901	5th St	500	St. Louis	Mo.	Teacher
1901	6th St	600	St. Louis	Mo.	Farmer
1901	7th St	700	St. Louis	Mo.	Banker
1901	8th St	800	St. Louis	Mo.	Druggist
1901	9th St	900	St. Louis	Mo.	Journalist
1901	10th St	1000	St. Louis	Mo.	Artist
1901	11th St	1100	St. Louis	Mo.	Writer
1901	12th St	1200	St. Louis	Mo.	Musician
1901	13th St	1300	St. Louis	Mo.	Actor
1901	14th St	1400	St. Louis	Mo.	Dancer
1901	15th St	1500	St. Louis	Mo.	Comedian
1901	16th St	1600	St. Louis	Mo.	Magician
1901	17th St	1700	St. Louis	Mo.	Acrobat
1901	18th St	1800	St. Louis	Mo.	Clown
1901	19th St	1900	St. Louis	Mo.	Trickster
1901	20th St	2000	St. Louis	Mo.	Stuntman
1901	21st St	2100	St. Louis	Mo.	Acrobat
1901	22nd St	2200	St. Louis	Mo.	Clown
1901	23rd St	2300	St. Louis	Mo.	Trickster
1901	24th St	2400	St. Louis	Mo.	Stuntman
1901	25th St	2500	St. Louis	Mo.	Acrobat
1901	26th St	2600	St. Louis	Mo.	Clown
1901	27th St	2700	St. Louis	Mo.	Trickster
1901	28th St	2800	St. Louis	Mo.	Stuntman
1901	29th St	2900	St. Louis	Mo.	Acrobat
1901	30th St	3000	St. Louis	Mo.	Clown
1901	31st St	3100	St. Louis	Mo.	Trickster
1901	32nd St	3200	St. Louis	Mo.	Stuntman
1901	33rd St	3300	St. Louis	Mo.	Acrobat
1901	34th St	3400	St. Louis	Mo.	Clown
1901	35th St	3500	St. Louis	Mo.	Trickster
1901	36th St	3600	St. Louis	Mo.	Stuntman
1901	37th St	3700	St. Louis	Mo.	Acrobat
1901	38th St	3800	St. Louis	Mo.	Clown
1901	39th St	3900	St. Louis	Mo.	Trickster
1901	40th St	4000	St. Louis	Mo.	Stuntman
1901	41st St	4100	St. Louis	Mo.	Acrobat
1901	42nd St	4200	St. Louis	Mo.	Clown
1901	43rd St	4300	St. Louis	Mo.	Trickster
1901	44th St	4400	St. Louis	Mo.	Stuntman
1901	45th St	4500	St. Louis	Mo.	Acrobat
1901	46th St	4600	St. Louis	Mo.	Clown
1901	47th St	4700	St. Louis	Mo.	Trickster
1901	48th St	4800	St. Louis	Mo.	Stuntman
1901	49th St	4900	St. Louis	Mo.	Acrobat
1901	50th St	5000	St. Louis	Mo.	Clown

WALTER J. FRANCIS & COMPANY.

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The foregoing report deals with the Niagara System in the past. A study of the future of the System is given in a separate report under date of June 23rd, 1923.

Walter J. Francis

Consulting Engineer.

Toronto, June 15th, 1923.

COPY

The enclosed report deals with the subject of the
study of the history of the United States in the
of the year 1912.

William L. Fleming

1000 PINE STREET, NEW YORK, N.Y.

WILLIAM L. FLEMING & COMPANY

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